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TERMINAL CONVECTIVE WEATHER FORECAST (TCWF) 2000 DEMONSTRATION REPORT

MEMPHIS INTERNATIONAL AIRPORT (MEM) MEMPHIS AIR ROUTE TRAFFIC CONTROL CENTER (ZME)

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June 2003

DOT/FAA/CT-TN03/6

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16. Abstract

The Terminal Convective Weather Forecast (TCWF) 2000 Demonstration was conducted during the convective season at Air Traffic Control (ATC) facilities in Memphis, TN. The demonstration was conducted by ACB-630 to ascertain the TCWF overall utility, ease of use, readability, and perceived benefit to ATC tasking. TCWF was developed at the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) under FAA Aviation Weather Research Program funding.

The product provides a graphical 0 to 60-minute forecast of convective weather for an airport terminal area.

Results indicated overall positive impressions. Users reported the TCWF provided benefit in performing ATC tasks; was a beneficial supplement to the Integrated Terminal Weather System (ITWS); and enhanced situational awareness.

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EXECUTIVE SUMMARY

The Terminal Convective Weather Forecast (TCWF) 2000 Demonstration was conducted during the convective summer season (between June and October 2000) to evaluate the product's operational suitability for Air Traffic Control (ATC) operations. The demonstration was planned and conducted by test personnel from the FAA William J. Hughes Technical Center (hereafter referred to as Technical Center), Weather Group (ACB-630) and funded by the FAA Aviation Weather Research Program (AWRP). The Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) developed the TCWF, which has undergone two previous iterations of operational and usability testing.

Demonstration sites included the Memphis International Airport (MEM) Terminal Radar Approach Control (TRACON) and the Memphis Air Route Traffic Control Center (ARTCC) (ZME) Traffic Management Unit (TMU). Participants included MEM TRACON Supervisors, and ZME TMU Traffic Management Coordinators (TMCs).

The purpose of the demonstration was to ascertain the TCWF: overall utility; ease of use; readability; and perceived benefit to ATC tasking as it relates to convective weather events.

The demonstration was conducted in two phases in order to capture both air-mass and line-storm convection. In this way, user impressions of the product during both of these weather phenomena could be captured. Data collection metrics included: questionnaires, structured interviews, and workload scales.

Results from both data collection phases were similar. Overall impressions of the TCWF were positive for both user groups. Differences in perceptions from data collected during Phase 1 and 2 were not significantly different.

All MEM TRACON users reported the TCWF provided benefit in performing tasks during operationally significant convective events, although Phase 2 results indicated a slightly less positive view (extremely useful vs. somewhat useful). In either phase, none of the task areas were rated negatively (i.e. no use). Also, for some task areas, frequency of use declined somewhat from Phase 1 to Phase 2 (most of the time vs. now and then).

ZME TMCs' perceptions for tasks were mostly positive. Although found very useful for MEM airspace impacts, the TCWF was not adequate for all airspace requirements, which comprises a majority of ZME operations.

Almost all users viewed the TCWF as a beneficial supplement to the Integrated Terminal Weather System (ITWS), where users reportedly preferred the TCWF areal weather coverage and 60-minute animated forecast over the ITWS Storm Extrapolated Position (SEP) 20-minute leading edge line depictions.

Overall data revealed that for most users (MEM and ZME), the TCWF enhanced situational awareness, and for MEM TRACON users, may have contributed to a decrease

in perceived operator mental workload in the performance of tasks affected by convective weather. Suggested product modifications included but were not limited to: improvement of forecast accuracy, especially for air-mass convection; both separation from and integration with the ITWS display platform; and use of a different color scheme for forecast depictions.

1. INTRODUCTION.

1.1 BACKGROUND.

The Federal Aviation Administration (FAA) Aviation Weather Research Program (AWRP) has sponsored the Massachusetts Institute of Technology Lincoln Laboratories (MIT/LL) in the development of a Terminal Convective Weather Forecast (TCWF). The TCWF graphically depicts a 0 to 60-minute forecast of convective weather for the terminal area. The TCWF is in its third iteration of operational demonstrations resulting in the current Build 3.

The purpose of the TCWF 2000 Demonstration was to collect user feedback regarding the utility, usability, and task benefit of Build 3 in order to effect improvements to the TCWF forecast and display. Another goal was to provide demonstration results to the FAA Integrated Terminal Weather System (ITWS) Program Office for consideration of the TWCF as a Pre-Planned Product Improvement (P3I) for testing and integration.

During the summer of 1998, the TCWF was demonstrated at the Dallas/Ft. Worth International Airport (DFW) and Ft. Worth Air Route Traffic Control Center (ARTCC). The FAA William J. Hughes Technical Center (hereafter referred to as Technical Center) and MIT/LL were responsible for the conduct of this demonstration. Overall, the forecast was viewed favorably by Terminal Radar Approach Control (TRACON) and ARTCC Traffic Management Coordinators (TMCs) as well as Center Weather Service Unit (CWSU) Meteorologists. The forecast was deemed useful for a number of task areas. Some minor display modifications were requested along with a request by ARTCC TMCs for longer forecast times.

During the 1999 convective weather season (June through October) Build 2 was again demonstrated at the Dallas TRACON and Dallas/Ft. Worth ARTCC. Demonstrations were also conducted, simultaneously, at the Orlando International Airport (MCO) TRACON and Jacksonville ARTCC (ZJX). Users consisted of TMCs, Supervisors, and CWSUs. Final results from the 1999 Demonstrations indicated product perceptions differed by location. These perceptions may be a function of the different weather phenomena encountered at each location.

Based on results from the 1999 Demonstration and internal product monitoring conducted by MIT/LL, changes were made to the forecast and accuracy scoring algorithms. For the year 2000 convective season, the TCWF was demonstrated at Memphis International Airport (MEM) TRACON and Memphis ARTCC (ZME) in each facility's respective Traffic Management Unit (TMU). Memphis sites were chosen because users were already familiar with using ITWS Situation Displays (SDs) but had not been exposed to the TCWF product. Participants included TMCs and Supervisors. Also, for the 2000 Demonstration, the TCWF was displayed on an ITWS SD platform. Although not integrated with ITWS, the display looked like the ITWS SD display, with activated alarms, status bars and Unix type graphical user interfaces (GUIs). This significantly changed the product's appearance from the 1998 and 1999 Demonstrations.

The TCWF 2000 Demonstration, conducted in two phases, endeavored to capture data on product perceptions during different types of convective weather activity (air-mass vs. line-storm

convection). Phase 1 data collection took place from July 27 through July 29, 2000; Phase 2 from November 7 through November 9, 2000.

Throughout the remainder of this report, Memphis International Airport and Memphis ARTCC will be referred to by their three-letter designators; MEM and ZME, respectively.

1.2 PURPOSE.

The purpose of this report is to summarize and report results on data collected during Phase 1 and Phase 2 at MEM TRACON and ZME. Conclusions and recommendations derived from these results are also reported with a description of the TCWF and demonstration overview.

1.3 SCOPE.

This report addresses the Phase 1 and Phase 2 user evaluation portion of the 2000 TCWF Demonstration. Additional analysis was conducted by personnel from MIT/LL, and may be submitted as a separate report.

2. REFERENCE DOCUMENTS.

FAA Acquisition Management System, Test & Evaluation Process Guidelines, June 1999.

Terminal Convective Weather Forecast Demonstration Plan and Procedures, May 2000, FAA William J. Hughes Technical Center, ACB-630.

1999 Terminal Convective Weather Forecast Demonstration Phase 1 & 2 Summary Report, December 1999, FAA William J. Hughes Technical Center, ACB-630.

Demonstration on the Usability of the 1999 Terminal Convective Weather Forecast (TCWF) Product for Air Traffic Control Managers, September 2000, FAA William J. Hughes Technical Center, ACB-630.

1998 Terminal Convective Weather Forecast Demonstration Summary Report, September 1998, FAA William J. Hughes Technical Center, ACB-630.

Handbook of Human Factors Testing and Evaluation, O'Brien, T., and Charlton, S. (eds.) 1996.

3. SYSTEM/PRODUCT OVERVIEW.

3.1 SYSTEM DESCRIPTION.

The TCWF used a method, labeled as the Growth and Decay Tracker, to determine the forecast of convective weather. The tracker is designed to separate large-scale (envelope) motion from small-scale cell motion of a storm. By effectively tracking the storm scale forcing, the forecast product is able to account for the systematic growth and decay of organized convective systems.

The TCWF algorithm process creates forecasts, out to 60 minutes incrementally, in ten-minute steps.

TCWF resolution is 1 kilometer (km) for ranges between 5 and 50 nautical miles (nm). A resolution of 2 km is used for ranges above 50 nm (100 and 200 nm). New images are created approximately every 6 minutes, depending on when the Next Generation Radar (NEXRAD) updates.

Changes to the TCWF from previous versions included updates to the accuracy-scoring algorithm. The criteria for this "User Scoring" technique included a forecast that was accurate to within 5 nm of actual weather. Overlaying a 5x5 pixel grid, any level 3 or above pixels were scored as hits and level 2 pixels as partial hits. The 1999 algorithm only scored the level 3 and above pixels. Therefore, accuracy scores should appear higher for Build 3. A thirty-minute running average of these scores constituted the forecast accuracy. Separate scoring was available for both the TRACON (50 nm) and longer range (200 nm) views.

For Memphis users, the TCWF display was a dedicated display and was delivered via leased phone lines from the Forecast Product Generator located at MIT/LL.

3.2 PRODUCT OVERVIEW.

3.2.1 Display Window.

The display window graphically presents past, current and forecast convective weather. Display ranges are initially displayed in two separate windows: 1) the TRACON Range (out to 50 nm) and 2) the Long Range (out to 200 nm). Other ranges may be user selected and are discussed in section 3.2.5.6 of this report. Other display depictions, i.e. overlays, windowing, and looping, are user selected from the window configuration and display configuration buttons. These items are discussed in subsequent sections of this report. Figure 1 shows an example of a 30-minute forecast display of the Memphis TRACON view.

3.2.2 ITWS Alerts.

ITWS alert buttons on the TCWF display are identical to the alerts on the ITWS display. If any alert is activated, it is visible on both displays. The TCWF product itself does not affect the ITWS alerts. ITWS alert buttons are shown in figure 1.

3.2.3 Product Status Buttons.

Product status buttons are located on the top left-hand side of the display, directly underneath display configuration buttons. The activated buttons show the status of the TCWF forecast product as well as the ITWS products connected to the alerts. These alerts included:

a. Tornado warning,
b. Lightning,

c. Gust front,
d. ASR (Airport Surveillance Radar) status,
e. ATIS (Automatic Information Server) status, and Forecast status.

The status button will be red if the product is not available for the airport in the active graphics window. If the product is available, the button will be green. Figure 1 depicts product status buttons.

3.2.4 Display Configuration Buttons.

Display configuration buttons are located on the top left hand side of the TCWF display (see figure 1) and are identical to the ITWS display configuration buttons. However, only the "Window" option is available on the TCWF display since the ITWS graphics window has been disabled.

3.2.4.1 Window Option.

Choosing the window option will allow for the selection of new forecast windows. Up to four forecast windows can be displayed for the Memphis airport. Users have the option to open a new window, restore a previous window, or close the current window.

3.2.5 Window Configuration Buttons.

Window configuration buttons are located on the right hand side of the display window. Each letter or symbol on the menu bar represents a display function using standard Unix symbology. For example, Z means "Zoom In" and "O" means "Overlay Menu". The window configuration buttons are identical to those on the ITWS display with the following exceptions:

a. Color-bar Toggle
b. Forecast Accuracy
c. Loop Settings, and
d. Start/Stop Loop Control.

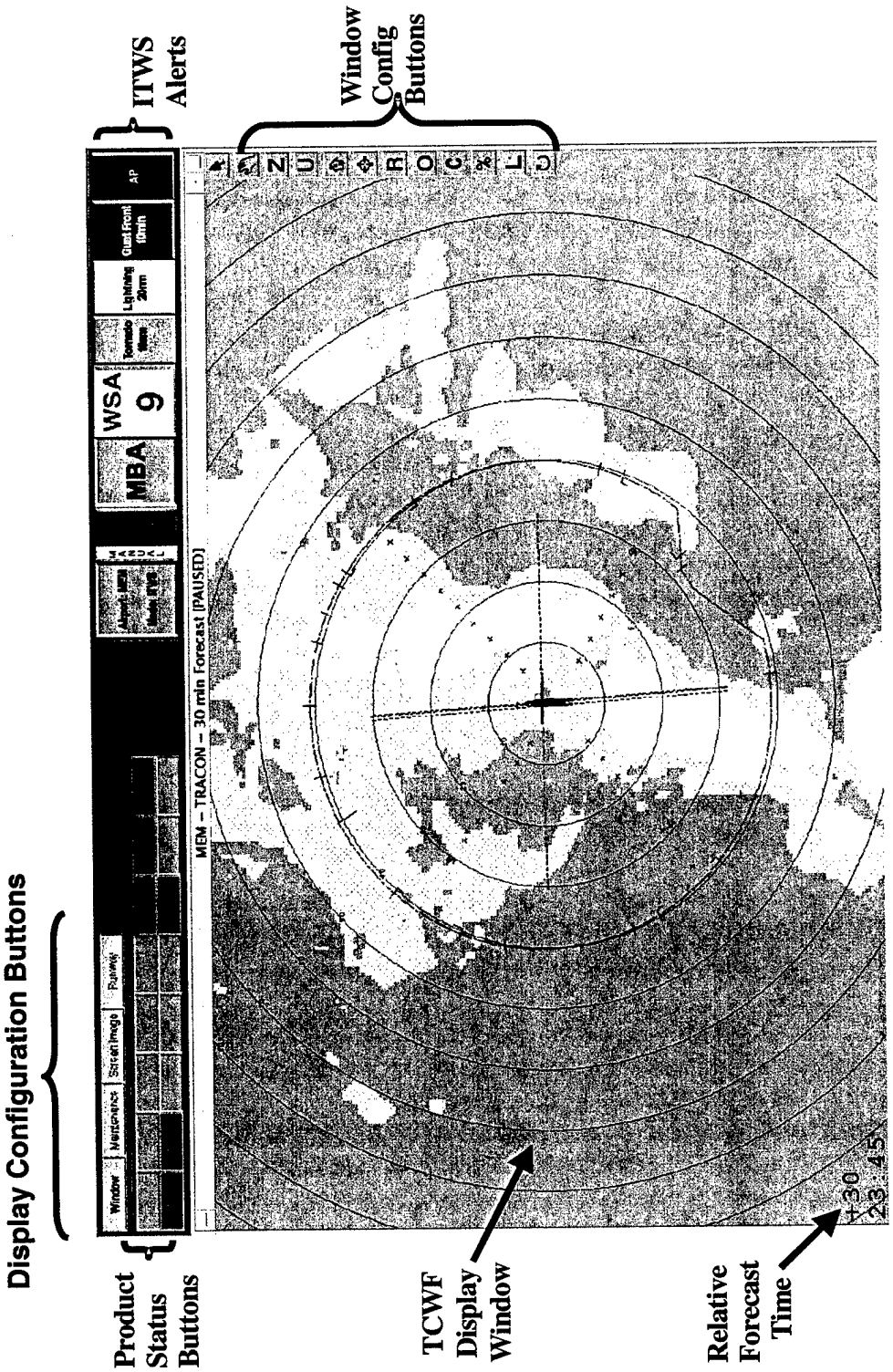

FIGURE 1. TCWF MEMPHIS DISPLAY WINDOW

Each window configuration button is described below and depicted in figure 2. Options that are italicized are unique to the TCWF display.

Product Interaction Mode (arrow)

Pan Interaction Mode (hand)

Zoom In (Z)

Zoom Out (Un-zoom) (U)

Home (house)

Re-center Interaction Mode (target)

Range Menu (R)

Overlay Menu (O)

Colorbar Toggle (C)

Forecast Accuracy (%)

Loop Settings (L)

Start/Stop Loop Control (circular arrow)

FIGURE 2. WINDOW CONFIGURATION BUTTONS

3.2.5.1 Product Interaction Mode.

Product interaction mode, represented by an arrow icon, allows cursor movement within a specified window.

3.2.5.2 Pan Interaction Mode.

Pan interaction mode, represented by a hand icon, enables movement of graphics within a specified display window.

3.2.5.3 Zoom In and Zoom Out.

Zoom in, or "Z" and Zoom Out, or "U" for "unzoom" incrementally zooms in or out of a graphical display window.

3.2.5.4 Home.

The home option, or house icon, will return a display graphic to its original default presentation.

3.2.5.5 Re-center Interaction Mode.

The re-center interaction mode option, represented by a target symbol, will automatically center a graphic within a display window.

3.2.5.6 Range Menu.

The range selection buttons allow the user to select the range of the display. Ranges between 5 nm and TRACON (50 nm) will use the 1 km product. The 100 nm and 200 nm ranges will use the 2 km product. Figure 3 depicts the range menu display.

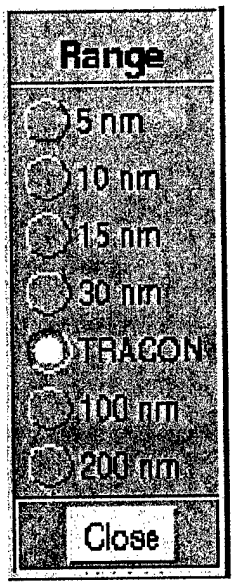

FIGURE 3. RANGE SELECTION MENU

3.2.5.7 Overlay Menu.

Geographical and areal locators may be overlaid on the active display window. By clicking on the overlay option the user may select or deselect any of the following:

a. Range rings
b. Navigational fixes
c. Outlying airports
d. Roads
e. Counties
f. Outer mark
g. Victor ways
h. Jet ways
i. High altitude select
j. Low altitude select

3.2.5.8 Color-bar Toggle.

The color-bar toggle scale (levels 1 - 6) indicates past weather. This scale is identical to the ITWS 6 level weather intensity color scale.

The predicted or forecast weather key shows regions in which the TCWF expects a moderate and high probability that level 3 or above weather (yellow, orange and red on the ITWS scale) will occur at the forecast time interval. Solid yellow is used for high probability regions and a hatched yellow/gray is used for moderate probability regions. Figure 4 graphically portrays the color-bar toggle.

FIGURE 4. COLOR-BAR TOGGLE

3.2.5.9 Forecast Accuracy.

The forecast accuracy or scoring display is illustrated in figure 5. This display provides users with real-time scoring information of TCWF accuracy. After forecasts have existed for 30 and 60 minutes, the forecast image is compared to the "truth" image or actual radar image and the accuracy of the forecast is scored. Past performance does not indicate the accuracy of the current forecast. Accuracy scores are available for both TRACON and 200 nm ranges.

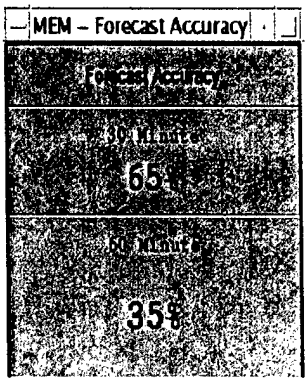

FIGURE 5. FORECAST ACCURACY DISPLAY

3.2.5.10 Loop Settings.

The movie loop selections, illustrated in figure 6, allow the user to select a variety of movie loops for displaying data. Loops range from past weather only to 30 or 60-minute forecasts. Past weather (back to 30 minutes) and forecasted weather can be looped together and are shown in 10-minute increments. Looping can occur with or without past weather. All images update automatically when new forecasts become available.

Three speed selections (slow, moderate, fast) are also available so users may adjust the speed of the animation.

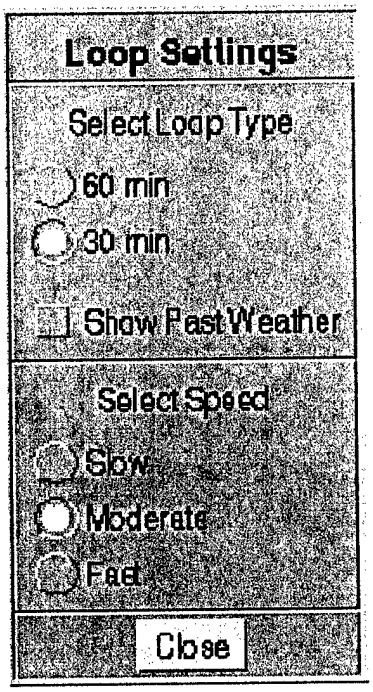

FIGURE 6. LOOP SETTINGS

3.2.5.11 Start/Stop Loop Control.

The start/stop loop control function, shown in figure 7, controls the starting and stopping of forecast loops. It also enables the user to display static forecast images.

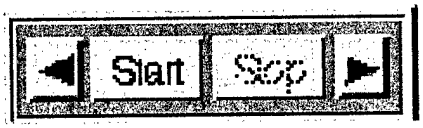

FIGURE 7. START/STOP LOOP CONTROL

3.2.6 Relative Forecast Time.

Figure 8 depicts the relative forecast time on the TCWF display. This is "relative time", or the time difference from the current time to the time of the weather shown in the display window. This time will be positive for the forecast images, and negative for past weather images. Actual time is displayed beneath the relative forecast time display.

The font will be white when the images are looping and will turn red when the loop has been stopped.

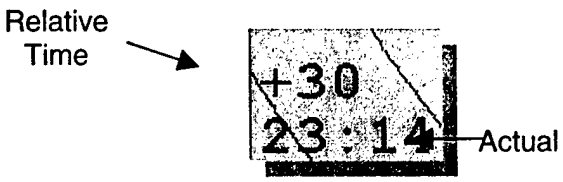

FIGURE 8. RELATIVE FORECAST TIME

3.2.7 Range Indicators.

A status bar at the top of the weather depiction display window indicates the range selected (i.e. TRACON or 200 nm) as well as the type of weather depiction (past, current or forecast).

4. DEMONSTRATION APPROACH.

The 2000 Demonstration addressed both positive and negative aspects of TCWF utility and data presentation. The demonstration also assessed how well TCWF met the job task and information requirements of the Memphis users. Results and collected data will be used to assist MIT/LL in improving both the display and performance of the TCWF. Additionally, results will be forwarded to the ITWS Program Office within the FAA for decisions regarding integration of the TCWF onto the ITWS platform.

Prior to demonstration conduct, ACB-630 evaluators collected baseline data at both the ZME TMU and MEM TRACON before introduction of the TCWF in their respective operations areas. This was to ensure baseline data would not be confounded by the presence of a new convective weather information system. The purpose of this baseline effort was to ascertain current procedures and weather information sources used during convective weather events. Evaluators also administered workload scales to subjectively measure users perceptions of mental workload while operating under convective conditions. Workload was administered again at the end of the Phase 2 data collection effort.

The purpose of Phase 1 data collection was to capture information regarding the utility, ease of use, and type of use of the TCWF during line-storm convective weather at Memphis. Phase 2 data collection focused on collecting feedback for both air-mass and line-storm convective weather. The purpose of using a phased approach was to capture differences in product performance and utility across different types of convective weather.

The FAA Technical Center (ACB-630) and MIT/LL conducted the TCWF Demonstration. Data collection took place at the demonstration sites listed in paragraph 4.4. Participants included:

a. Traffic Management Supervisors (Sups), and
b. TMCs

ACB-630 test personnel conducted the TCWF Demonstration. Participants utilized the TCWF during convective weather events. Based on TCWF operational use, evaluators assessed TCWF using various demonstration techniques described in section 4.2.

4.1 DEMONSTRATION OBJECTIVES.

The primary objectives of the demonstration were:

a. To determine the overall utility of the TCWF including:

   1. Incremental forecasts out to 60 minutes, and
   2. Scoring methodology.

b. To determine the ease of use of current display concepts, more specifically:

   1. Overlay presentation,
   2. Color coding,
   3. Animation, and
   4. Product presentation on an ITWS-type SD using Unix based GUIs.

c. To determine if the TCWF enhances the users' ability to make informed and timely operational decisions in determining whether or not to perform specific tasks (e.g., open/close approach gates, meter traffic) during convective weather.

4.1.1 Definitions of Measures.

This paragraph will define important terms used in the description of demonstration objectives. The terms are as follows:

a. Utility - This refers to how useful the TCWF is in completing job tasks related to traffic planning as impacted by convective weather. For this demonstration, utility was measured subjectively according to questionnaire ratings. A user could consider a feature useful if it:

   1. Improves his/her situational awareness,
   2. Positively impacts his/her decision making, and/or
   3. Positively impacts his/her workload.

It is important to keep in mind that utility and ease of use are distinctly different. A product may be very easy to use, but the product might not provide a user with useful information.

b. Ease of Use - This refers to how easy the forecast is to use in completing job tasks (i.e., navigation, button use). A user may consider a feature easy to use if he/she can access information on the display with little difficulty and can easily discriminate display characters and symbols. As mentioned above, ease of use and utility are different. A product may be very useful, but may be very difficult to use.

c. Readability - This refers to the extent the information displayed is easy to see, readable, meaningful, and understandable. For example, overlaid text may be too small to read or obscured by other overlays.

d. Situational Awareness - Situational Awareness (SA) is generally known as the perception of elements in the environment, an understanding of what these elements mean, and how they will affect the near future. In order to maintain SA, it is important that users perceive and understand elements in the present situation and use this information to anticipate future events. The extent that operators perceived the effects of the TCWF on SA was addressed.

4.2 DEMONSTRATION METRICS.

The objectives of the TCWF Demonstration were achieved by obtaining feedback from air traffic users. This section will describe the demonstration techniques and measurement tools. User data collection incorporated the following techniques:

a. Questionnaires,
b. User interviews, and
c. Workload scales.

4.2.1 Questionnaires.

Questionnaires were administered at the end of Phases 1 and 2. Using a 5-point Likert scale, demonstration participants rated various aspects of the TCWF based on utility, operational suitability, and frequency of use as related to specific job tasks. Participants also rated the product functions and components on ease of use, utility, and readability in order to identify good interface concepts for future iterations of the display. The questionnaire also included open-ended questions that allowed users to identify aspects of the TCWF they felt needed improvement. Given the differences in air traffic tasks for each position and location (i.e., ARTCC vs. TRACON), separate questionnaires were developed for each user group and location. The questionnaires were very similar in nature to allow evaluators to create comparisons between groups; however, the uniqueness of each questionnaire enabled evaluators to identify specific user needs. Questionnaires are located in appendix A.

4.2.2 Interviews.

Interview questions were designed to obtain user impressions on the product in terms of task benefit, utility, product performance, benefit beyond ITWS, and suggested enhancements to better meet user requirements. Interviews were conducted with individual users from both MEM and ZME during both Phases 1 and 2. Structured interview questions and responses are located in appendix B.

4.2.3 Workload Scales.

The Modified Cooper Harper (MCH) mental workload scale was used to measure overall perceived user mental workload as it applied to operational use of the TCWF display. The MCH is a unidimensional subjective workload scale which measures mental workload associated with a variety of perceptual, cognitive, and communications tasks. The MCH is a sensitive measure and is widely applicable to a variety of operator tasks. Essentially, the scale is a decision tree that leads the user to one of 10 ordinal ratings (O'Brien & Charlton (eds.) 1996).

During baseline data collection, the MCH was administered to capture current perceptions of mental workload associated with significant convective weather events actually or potentially impacting air traffic operations. Affected task areas were identified and verified by users. MEM TRACON tasks, for example, included changing runways, and closing arrival gates. Tasking for ZME TMC users included decisions affecting Miles-In-Trail (MIT), and determining holding areas. At the end of the final demonstration phase, the MCH was administered to the same users who initially completed the MCH during the baseline phase. Comparisons of both iterations (pre and post) of the MCH were compared to see if perceived mental workload increased, decreased, or remained the same after introduction of the TCWF in the operational environment. A sample workload scale for one of the MEM TRACON tasks is located in appendix C. Remaining tasks used an equivalent scale and are identified in section 6.4.

4.3 DATA ANALYSIS.

Data was summarized and tabulated. Questionnaire and workload ratings were analyzed using descriptive statistics. Structured interview responses were summarized. Results are presented in tabular and graphical formats in section 6. Since ranking data was ordinal and a normal distribution could not be assumed, the median was used as the measure of central tendency.

4.4 DEMONSTRATION SITES.

TCWF displays were located in both non-operational and operational settings. MIT/LL and FAA personnel had access to the TCWF in non-operational settings. Non-operational settings included:

a. MIT/LL; Lexington, MA and
b. FAA William J. Hughes Technical Center, Atlantic City, NJ.

The users utilized the TCWF in operational settings during convective weather. The demonstration took place at the following operational sites:

a. FAA MEM TRACON; and
b. FAA ZME TMU.

5. DEMONSTRATION MANAGEMENT.

ACB-630, working as a member of the Weather Sensors and Aviation Weather Research Integrated Product Team (IPT) (AUA-430), and in conjunction with MIT/LL, had overall responsibility for the conduct and coordination of the TCWF Demonstration.

The principle organizations participating in the demonstration included:

a. AUA-430, FAA Headquarters, Washington, DC;
b. ACB-630;
c. MIT/LL;
d. MEM TRACON; and
e. ZME.

6. RESULTS.

Results from data collected during TCWF Demonstration Phases 1 and 2 will be addressed separately in this section.

6.1 FACTORS EFFECTING RESULTS.

Before and during the demonstration period, some potential issues arose that may have impacted the results and should be taken into consideration when reviewing this report. Therefore, conclusions derived from these results should be weighed carefully. Factors effecting results included the following:

Lack of Convective Weather – Operationally significant convective weather events were infrequent. Due to lack of convective weather, infrequency of use was reported by a number of demonstration participants resulting in fewer opportunities to fully utilize the TCWF. For demonstration purposes, more opportunities for TCWF use would have provided better insight into user perceptions of the product.

Training Bias - TCWF training was conducted at the end of March 2000 by MIT/LL personnel to all TCWF Memphis participants prior to TCWF Demonstration conduct. Some of the training material included positive results obtained from the TCWF 1999 Demonstration, as well as data on forecast accuracy performance from Dallas and New York. Dallas TRACON user comments were taken out of context and did not include any negative feedback, i.e. "It (TCWF) is very useful" and "will be beneficial to pilots". If Memphis sites were assumed to be "clean" (no previous exposure to TCWF), then introduction of this data violated that assumption. Users may have been favorably biased in their perception of the TCWF prior to its operational availability. If so, TCWF Demonstration results may reflect this bias.

6.2 STRUCTURED INTERVIEW RESULTS.

6.2.1 Phase 1 Interview Results.

Users were interviewed during the Phase 1 data collection period using the structured interview questions located in appendix B. Eight users (out of total number of 15 TMCs) were interviewed at the ZME TMU and five users (out of total of 10 Supervisors) at the MEM TRACON. User responses are summarized for each question. Additionally, a table is provided for each question to provide an overall summary regarding the number of users who responded with a positive, negative, or neutral response. Some descriptive words/phrases are used for clarity. Phase 1 interview responses for each user are summarized in appendix B.

1. What is your overall impression of the TCWF?

MEM TRACON users were positive overall. Many found the TCWF very useful as a source for terminal convective weather information.

Generally, ZME users' overall impression of the TCWF product was favorable. Many used the TCWF for MEM arrival strategies, rerouting, and flow management. Users reported the forecast component and animated storm movement capability as the most desirable attributes of the product. Conversely, one user reported not using the product due to poor accuracy scores, lowering expectations of the product's forecast capability. Table 1 provides overall TCWF impressions from each user group.

TABLE 1. OVERALL TCWF IMPRESSION

USER GROUP	POSITIVE	NEGATIVE	NO OPINION
ALL USERS (N=13)	12	1	0
MEM Sups (N=5)	5	0	0
ZME TMCs (N=8)	7	1	0

2. Has the product helped you perform any specific tasks? If yes, what are those tasks and how did the TCWF help?

All MEM TRACON users reported that the TCWF helped in performing specific tasks listed in table 2. The TCWF helped by predicting where gates, holding areas, and runways would be impacted by convection, allowing MEM users to plan accordingly.

Five of the ZME users reported the TCWF helped in performing specific tasks. Most noted are listed in table 2. In these instances the TCWF animated storm movement and forecast capabilities were most helpful in task areas like planning gate closures or anticipating traffic flows. One user noted the graphic display and animation were very useful components for visualizing weather movement. Another ZME user noted increased shared situational awareness with MEM approach control, stating "we were both looking at the same picture and could focus on the same view."

One ZME TMC was reluctant to use the TCWF based on its experimental status. Another ZME user reported never using the TCWF since ITWS was adequate.

TABLE 2. TCWF TASK BENEFIT

USER GROUP	YES	TASK BENEFITS	NO	NO OPINION
ALL USERS (N=13)	10	See Below.	2	1
MEM Sups (N=5)	5	a. Flow control. b. Holding. c. Terminal routing. d. Runway reconfigurations. e Determining Airport Arrival Rate (AAR).	0	0
ZME TMCs (N=8)	5	a. Discontinue holding. b. Rerouting. c. Gate impacts. d. Anticipating AAR.	2	1

3. *Has the product hindered your ability to perform any specific tasks? If yes, what are those tasks and how did the TCWF hinder them?*

All MEM TRACON users reported no hindrances in using the TCWF product. One noted that for air-mass convection, product use was infrequent since the product did not perform well under air-mass conditions.

All of the Memphis ARTCC users found no negative impacts in using the TCWF. One user noted that by not using the product, there could be no negative impacts. Table 3 provides a summary of responses regarding negative task impacts.

TABLE 3. TASK IMPACTS

USER GROUP	YES	TASK HINDERED	NO	NO OPINION
ALL USERS (N=13)	0	None	13	0
MEM Sups (N=5)	0	None	5	0
ZME TMCs (N=8)	0	None	8	0

4. *Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial?*

All MEM TRACON participants reported benefit beyond ITWS. Two respondents noted that the TCWF gives a better visual weather depiction than ITWS and that the TCWF forecast and storm movement components were beneficial. Table 4 summarizes responses regarding TCWF benefit beyond ITWS along with helpful TCWF features.

Almost all (7) ZME users found TCWF provided benefit beyond ITWS. TCWF enabled them to better time weather movement and ascertain how and when the MEM terminal area would be affected. TCWF features found to be most helpful included the forecast component and storm movement projections or animated forecast projections. It was noted that the product was mostly used for the terminal area, although a 200 nm projection was available. One respondent noted that MEM only effects 20% of their operations; therefore, the TCWF did not fulfill requirements for a majority of operations within ZME airspace. One respondent noted no benefit beyond ITWS since the TCWF forecast was inaccurate.

TABLE 4. TCWF BENEFIT BEYOND ITWS

USER GROUP	YES	HELPFUL TCWF FEATURES	NO	NO OPINION
ALL USERS (N=13)	12	See Below.	1	0
MEM Sups (N=5)	5	a. Forecast. b. Storm movement. c. Graphical weather depiction.	0	0
ZME TMCs (N=8)	7	a. Forecast. b. Storm movement.	1	0

5. *Has the TCWF enabled you to more efficiently handle the flow of traffic into or out of your (MEM or ZME) airspace during convective weather? If yes, what information does the TCWF provide that helps?*

All MEM TRACON participants reported the TCWF enabled them to more efficiently handle the flow of traffic into or out of their airspace during convective weather. Users noted helpful TCWF information included the 30-and 60-minute forecasts and forecast accuracy scores.

Seven ZME participants found TCWF helpful in handling traffic flow during convective weather events as shown in table 5. Again, it was noted that the greatest benefit was to anticipate MEM terminal impacts. There was little to no perceived benefit for the rest of ZME airspace.

TABLE 5. TRAFFIC FLOW BENEFIT

USER GROUP	YES	HELPFUL TCWF INFORMATION	NO	NO OPINION
ALL USERS (N=13)	12	See Below.	0	1
MEM Sups (N=5)	5	a. Forecast. b. Accuracy scores.	0	0
ZME TMCs (N=8)	7	a. Terminal weather. b. Forecast.	0	1

6. *Could the TCWF be modified or improved to make it more useful? How?*

Suggestions for improvement from both MEM TRACON and ZME participants are summarized in table 6. Some MEM users did not want to combine the TCWF with the ITWS platform, but leave as a stand-alone display. Users explained that this would make TCWF access less cumbersome and reduce display clutter. Given the integrated option, one TMC suggested testing the TCWF/ITWS product before operational implementation.

Two MEM TRACON users indicated that training was insufficient to fully utilize the TCWF operationally. One user found the forecast color intensity (yellow and yellow-hatched presentations) to be confusing and suggested using standard ITWS level weather intensity colors (i.e. the color red denoting the highest intensities).

One ZME user suggested improving the forecast presentation by indicating, by text or some other indicator, when an area of airspace would be clear or when weather would impact it (i.e., storms will be north of the airport for the next 20 minutes). Two TMCs noted the forecast accuracy should be improved. Another suggested a larger display would improve readability of the display.

TABLE 6. SUGGESTED TCWF MODIFICATIONS

USER GROUP	MODIFICATIONS/IMPROVEMENTS
MEM Sups (N=5)	a. Keep separate from ITWS. b. Include gust front and wind information. c. Integrate with ITWS as a separate window. d. Improve TCWF training. e. Forecast weather intensity level colors should be the same as those used on ITWS.
ZME TMCs (N=8)	a. Improve growth and decay capability. b. Improve forecast accuracy. c. Integrate with ITWS. d. Include a ZME boundary map overlay. e. Increase product range to include all ZME airspace. f. Larger display monitor.

6.2.2 Phase 2 Interview Results.

Participants were interviewed at both MEM and ZME sites. These included five MEM TRACON Sups and twelve ZME TMCs.

1. What is your overall impression of the product? Has that impression changed since mid-July? If so, how?

Consistent with Phase 1 results, overall impressions of the TCWF product for most users from both MEM TRACON and the ZME TMU were positive. See table 7 for a summary of comments.

TABLE 7. TCWF OVERALL IMPRESSION

USER GROUP	POSITIVE	NEGATIVE	NO OPINION
ALL USERS (N=17)	15	1	1
MEM Sups (N=5)	4	0	1
ZME TMCs (N=12)	11	1	0

Responses included words/phrases such as: "great", "good product", "like the product", and "impressed with the product". One ZME TMC noted that although favorably impressed by the TCWF, confidence in its accuracy during air-mass convection decreased.

One ZME user responded negatively, stating there was no use for the TCWF since it only focused on one small area of ZME airspace and was mostly used for anticipating runway impacts.

One MEM TRACON user had no opinion, explaining convective weather events had been too infrequent to fully utilize the product.

2. *Has the product helped you perform any specific tasks? If yes, what are those tasks and how did the TCWF help?*

All MEM TRACON users reported some TCWF task benefit and reported it helpful for general planning purposes. TCWF aided planning by forecasting where convective weather would be and when it would move into or leave an area (i.e. fix, runway, airport). The TCWF reportedly benefited several tasks (see table 8) such as opening/closing gates, and changing runway configurations.

Most ZME users (10) also indicated the TCWF provided task benefit. Overall it was considered a good planning tool by providing a general indication of when weather would impact MEM. The TCWF reportedly benefited specific tasks (see table 8) such as traffic flow planning based on MEM airport weather impacts, and arrival and departure gate impacts.

TABLE 8. TCWF TASK BENEFIT

USER GROUP	YES	TASKS BENEFITED	NO	NO OPINION
ALL USERS (N=17)	15	See Below.	0	2
MEM Sups (N=5)	5	a. Open/close gates/fixes. b. Change runway configuration. c. Determine holding at fixes. d. Anticipate MIT. e. Plan traffic flow/reroutes. f. Open/close airport. g. Improved SA with ZME.	0	0
ZME TMCs (N=12)	10	a. Ascertain weather impact on MEM. b. Plan arrival and departure gate impacts. c. Determine holds. d. Plan traffic flow. e. Anticipate MIT f. Shared SA with MEM TRACON.	0	2

3. *Has the TCWF enabled you to more efficiently handle the flow of traffic into or out of MEM or ZME airspace during convective weather? If yes, what information does the TCWF provide that helps?*

All MEM TRACON users reported the TCWF enabled them to more efficiently handle the flow of traffic into and out of MEM airspace. Information reported to be most helpful included the incremental forecast and storm movement projections

Most ZME TMC users (10) reported TCWF benefit in handling traffic flow around MEM airspace, but not all of ZME airspace. Two users had no opinion. Similar to MEM responses, ZME users found the forecast and forecast weather movement (animation) components most helpful. See table 9 for user response summaries.

TABLE 9. TRAFFIC FLOW BENEFIT

USER GROUP	YES	HELPFUL TCWF INFORMATION	NO	NO OPINION
ALL USERS (N=17)	15	See Below.	0	2
MEM Sups (N=5)	5	a. Incremental forecast. b. Weather movement.	0	0
ZME TMCs (N=12)	10	a. Incremental forecast. b. Weather movement.	0	2

4. *Do you recall any convective weather scenarios that had impacted MEM/ZME airspace? If so, was the TCWF used for this weather event? For what tasks?*

Many users recalled specific or general instances of using the TCWF in performance of some tasks. All recollections of TCWF performance were positive and are summarized in table 10.

Two MEM users recalled TCWF use during line-storm convective weather, particularly for holding situations (i.e. when to take aircraft out of holding). One MEM user reported using the TCWF for making runway changes, determining flow rates and anticipating arrival and departure impacts. Additional information sources included ITWS, ASR-9 radar, and the Aircraft Situation Display (ASD). Two MEM users had no specific recollection.

Four ZME users reported TCWF use during line-storm convection. Two TMCs made comments based on use during general convective weather situations. The TCWF was reportedly accurate and helpful in performance of many tasks, including traffic flow management, anticipating arrival/departure gate, and MEM airport impacts as well as anticipating MIT restrictions and determining when to take aircraft out of holding. Other weather information sources included the CWSU, WARP Briefing Terminal, and ITWS. Four ZME users had no specific recollections of TCWF use.

TABLE 10. TCWF USE DURING CONVECTIVE WEATHER EVENTS

USER GROUP	CONVECTIVE WX EVENT	TCWF USE	OTHER WX INFOR
MEM Sups (N=3)	Yesterday a line (of thunderstorms) passed through. Was about 300-400 miles long.	Was able to predict when aircraft could come out of holding. Nailed forecast with only 1 aircraft having to divert. TCWF used for about 70-80% of planning.	ITWS for intensity levels. ASR-9 radar.
	Used 3-4 times with line-storm situations.	Used to determine going into holdings and coming out, and changing runway configurations.	ASD Fed-ex weather conference call.
	General convective events.	Used TCWF for runway changes, flow rates, anticipating impacts to arrivals and departures, and being able to predict where weather will be. Used TCWF in conjunction with other products.	ITWS SEP
ZME TMCs (N=6)	Last night (11/6) had a line of thunderstorms from about 100 miles south of MEM to about 80 miles north of MEM.	Used to determine miles-in-trail and holding. Was able to spread aircraft out to make a manageable situation; held aircraft and brought them in on the back side of the line; and able to minimize holding time and bring aircraft in as soon as weather cleared MEM. Product had good accuracy in this event.	

TABLE 10. TCWF USE DURING CONVECTIVE WEATHER EVENTS (Continued)

USER GROUP	CONVECTIVE WX EVENT	TCWF USE	OTHER WX INFOR
	Line of storms on 11/6.	Yesterday's weather situation was a good example of how TCWF has been used. Was able to predict approximate times to move aircraft to gates; did not have to divert because of TCWF information.	
	Line of storms on 11/6.	Forecasted accurately by TCWF, which was only off by 10 minutes with airport arrivals. Due to TCWF information, knew aircraft had to be moved north around the line and brought in on the backside of the line. Relied solely upon the TCWF.	
	General convective weather use.	TCWF forecasts are easier to interpret than ITWS. Can tell if airport will be impacted and if MIT and spacing are needed. With ITWS, have to assume airport will be impacted due to the lack of forecast information. Line-storms tend to be more accurate; isolated storms are harder to predict. However, attention is paid when TCWF is forecasting something with isolated storms.	ITWS
ZME TMCs (N=6)	Line of storms on 11/6.	Discussed TCWF output with CWSU to see what they think. (i.e. if forecast portrayal is viable).	CWSU WARP - to get bigger picture.
	General convective weather use.	Used TCWF to monitor the weather and pass information to other Centers to avoid overloading sectors. Have used TCWF information for justification of Center decisions to ATCSCC.	

5. *Has the product hindered your ability to perform any specific tasks? If yes, what are those tasks and how did the TCWF hinder them?*

No user from either facility (MEM or ZME) reported hindrances to tasking by using the TCWF product. Table 11 provides a summary of responses to this question.

TABLE 11. TASK IMPACTS

USER GROUP	YES	TASK HINDERED	NO	NO OPINION
ALL USERS (N=17)	0	None	16	1
MEM Sups (N=5)	0	None	5	0
ZME TMCs (N=12)	0	None	11	1

6. *Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial?*

All MEM TRACON users reported TCWF benefit beyond ITWS. Many considered the 1-hour animated forecast and areal storm coverage of the TCWF an improvement over the ITWS SEP 20-minute forecast of the storm's leading edge.

Most ZME users (9) found TCWF provided benefit beyond ITWS. Again, the forecast and forecast portrayal (animation and area coverage) were considered the greatest TCWF assets. Two users reported no TCWF benefit beyond ITWS since the TCWF does not include wind information, and forecasts are not always reliable. Table 12 provides a summary of reported TCWF benefit beyond ITWS.

TABLE 12. TCWF BENEFIT BEYOND ITWS

USER GROUP	YES	HELPFUL TCWF FEATURES	NO	NO OPINION
ALL USERS (N=17)	14	See Below.	2	1
MEM Sups (N=5)	5	a. Better/longer forecast prediction than ITWS SEP. b. Better visual forecast presentation than ITWS.	0	0
ZME TMCs (N=12)	9	a. Forecast. b. Forecast animation.	2	1

7. *Did the 30- and 60-minute forecast accuracy scores effect your decision to use or not use the TCWF?*

Three of the five MEM TRACON users reported not using forecast accuracy scores to base decisions on TCWF use. The remaining users (2) indicated accuracy scores did affect their decision to use or not use the TCWF product. Criteria for score use were not specific, although these users indicated that if scores were low, the product would not be relied on. Conversely, if scores were higher, forecast accuracy would be confirmed and likelihood to use the product increased.

Most (7) ZME users reported using forecast accuracy scores to determine whether or not to use the TCWF product, whereas five users did not. Accuracy score criteria for product use included scores above 40% to scores above 75%. Table 13 summarizes user responses for accuracy score use and criteria.

TABLE 13. USE OF ACCURACY SCORES AND CRITERIA FOR USE

USER GROUP	USED SCORES	WHY USED	DID NOT USE SCORES	WHY NOT USED
ALL USERS (N=17)	9	See Below.	8	See Below.
MEM Sups (N=5)	2	a. Would not rely on TCWF if scores were low. b. Higher scores would confirm accuracy, esp. w/ line-storms.	3	a. Make decisions to use TCWF based on forecast image. b. Only need 30 min. outlook. Scores unimportant.
ZME TMCs (N=12)	7	a. Scores > 40% b. Scores > 50% c. Scores > 70% d. Scores > 75%	5	a. Unimportant during line-storms. b. Waste of space.

8. Could the TCWF be modified or improved to make it more useful? How? Do you have any comments or concerns regarding the forecast product?

Suggestions for improvements/modifications to the TCWF as well as additional comments regarding the forecast product are summarized in table 14.

TABLE 14. SUGGESTED TCWF MODIFICATIONS/COMMENTS

USER GROUP	MODIFICATIONS/IMPROVEMENTS
MEM Sups (N=5)	a. Incorporate wind direction and velocity. b. Improve training. c. Keep separate from ITWS. d. If integrated with ITWS, display on larger monitor. e. Make available to controllers.
ZME TMCs (N=12)	a. Integrate TCWF with ITWS. b. Keep TCWF separate from ITWS. c. Increase product range. d. Improve accuracy. e. Include overlays of Centers, fixes, and counties. f. Provide longer (to 1 hr.) past history of weather. g. Make available to controllers. h. Wider map boundary lines for easier discernability. i. Effective and trustworthy - needs to be at other locations (i.e. Federal Express).

6.3 QUESTIONNAIRE RANKING RESULTS.

This section will describe the results from the questionnaires from both Memphis facilities for data collection Phases 1 and 2. Results will be discussed separately for the interface and job task portions of the questionnaires.

6.3.1 Phase 1 Interface Questions.

Questionnaire ranking results regarding the TCWF interface and functionality are summarized in table 15 for all users, MEM TRACON users only, and ZME TMU users only for each product feature. For a definition of measures, see section 4.1.1. Rating scale weights are defined under corresponding tables.

In general, users rated the product features favorably. All product features received suitability ratings of moderately suitable to totally suitable on the dimensions of utility, readability, and ease of use.

TABLE 15. MEDIAN SCORE PER FEATURE

	ALL USERS (N=12)			MEM SUPS (N=5)			ZME TMCS (N=7)		
Product	Utility	Read	Ease	Utility	Read	Ease	Utility	Read	Ease
Display Window	5	5	5	5	5	5	5	4	5
Time Display	5	5	N/A	5	5	N/A	5	5	N/A
Range Indicators	5	5	5	5	5	5	5	5	5
Forecast Color Scale	5	5	N/A	5	5	N/A	5	5	N/A
Movie Loop	5	5	5	5	5	5	5	5	5
Loop Control	5	5	5	5	5	5	5	5	5
Forecast Accuracy Score	4.5	5	N/A	5	5	N/A	4	5	N/A
Overlays	5	5	5	5	5	5	4	4.5	5
Windowing Options	5	5	5	5	5	5	5	5	5
Status Indicators	5	5	N/A	5	5	N/A	4	4	N/A

Note: Median values are reported for utility, readability (Read), and ease of Use (Ease) for each feature. Scale: 1 = Totally Unsuitable, 2 = Moderately Unsuitable, 3 = Suitable with Modification, 4 = Moderately Suitable, 5 = Totally Suitable.

Table 16 summarizes user responses regarding the OPTIMAL FORECAST LENGTH required for tasks during convective weather. MEM TRACON users were split between 60 and 90-minute forecast durations. One preferred a 30-minute forecast.

Similar results were obtained from ZME users where three preferred the existing 60-minute forecast and three a 90-minute forecast. One user preferred the existing 30-minute forecast.

TABLE 16. FREQUENCY OF RESPONSES - OPTIMAL FORECAST LENGTH

USER GROUP	30 MINUTES	60 MINUTES	90 MINUTES	120 MINUTES
ALL USERS (N=12)	2	5	5	0
MEM Sups (N=5)	1	2	2	0
ZME TMCs (N=7)	1	3	3	0

Table 17 summarizes user responses regarding the amount of time the TCWF is viewed from the 50 NM (TRACON) RANGE. Mean percentage of time MEM TRACON users viewed the TCWF at 50 nm was 69%. Mean viewing time for ZME users and all users was 68%.

TABLE 17. MEAN PERCENTAGE - TIME THE 50 NM RANGE IS VIEWED

USER GROUP	%
ALL USERS (N=12)	68
MEM Sups (N=5)	69
ZME TMCs (N=7)	68

Table 18 summarizes user responses regarding the amount of time the TCWF is viewed from the 200 NM RANGE. MEM TRACON users indicated the 200 nm range was viewed an average of 31% of the time. Mean percentage time ZME users viewed the 200 nm range was somewhat higher, at 38%. Mean viewing time for all users was 35%.

TABLE 18. MEAN PERCENTAGE - TIME 200 NM RANGE IS VIEWED

USER GROUP	%
ALL USERS (N=12)	35
MEM Sups (N=5)	31
ZME TMCs (N=7)	38

Table 19 summarizes user responses regarding their need for a RANGE GREATER THAN 200 NM. Seven users indicated the 200 nm range was sufficient; however, ZME users preferred a 300 to 450 nm range to obtain a better view of total ZME airspace. One TRACON user indicated a range beyond 200 nm would be optimal, however, the optimal range was not reported.

TABLE 19. FREQUENCY OF RESPONSES - RANGE GREATER THAN 200 NM

USER GROUP	YES	OPTIMAL RANGE	NO
ALL USERS (N=12)	5	See Below.	7
MEM Sups (N=5)	1	N/A	4
ZME TMCs (N=7)	4	300 nm - 450 nm	3

Table 20 summarizes user responses regarding perceptions on the accuracy of the FORECAST ACCURACY SCORE. The majority of users responded with "yes", the forecast accuracy score matched their impressions of the actual forecast. Two ZME participants had no opinion.

TABLE 20. FREQUENCY OF RESPONSES - FORECAST ACCURACY SCORE

USER GROUP	YES	NO	N/A
ALL USERS (N=12)	10	0	2
MEM Sups (N=5)	5	0	0
ZME TMCs (N=7)	5	0	2

6.3.2 Phase 2 Interface Questions.

Phase 2 questionnaire ranking results regarding the TCWF interface and functionality are summarized in table 21 for all users, MEM TRACON users only, and ZME TMU users only for each product feature. In general, users rated the product features favorably. All product features received suitability ratings of moderately suitable to totally suitable on the dimensions of utility, readability and ease of use.

TABLE 21. MEDIAN SCORE PER FEATURE

	ALL USERS (N=16)			MEM SUPS (N=5)			ZME TMCS (N=11)		
Product	Utility	Read	Ease	Utility	Read	Ease	Utility	Read	Ease
Display Window	5	5	4.5	5	5	4	5	5	5
Time Display	5	5	N/A	5	5	N/A	5	5	N/A
Forecast Color Scale	5	5	N/A	5	5	N/A	5	5	N/A
Movie Loop	5	4	4	4	4	4	5	5	5
Loop Control	4	5	4.5	4	4	4	5	5	5
Forecast	5	5	N/A	5	5	N/A	5	4	N/A
Accuracy Score									
Overlays	5	5	5	5	5	5	5	5	5
Windowing Options	5	5	5	5	4	4	5	5	5
Status Indicators	5	4.5	N/A	5	5	N/A	5	5	N/A

Note: Median values are reported for utility, readability (Read), and ease of Use (Ease) for each feature. Scale: 1 = Totally Unsuitable, 2 = Moderately Unsuitable, 3 = Suitable with Modification, 4 = Moderately Suitable, 5 = Totally Suitable.

Table 22 summarizes user responses regarding the OPTIMAL FORECAST LENGTH for their tasks during convective weather. Many users indicated the available 60-minute forecast was the optimal forecast duration. MEM TRACON responses were consistent with Phase 1 results, where four users found the existing 60-minute forecast optimal. The majority of ZME users (7) also preferred the 60-minute forecast. Only one ZME user requested a forecast duration out to 120 minutes. The 90-minute forecast was not considered optimal by any users.

TABLE 22. FREQUENCY OF RESPONSES - OPTIMAL FORECAST LENGTH

USER GROUP	30 MINUTES	60 MINUTES	90 MINUTES	120 MINUTES
ALL USERS (N=15)	3	11	0	1
MEM Sups (N=5)	1	4	0	0
ZME TMCs (N=10)	2	7	0	1

Table 23 summarizes user responses regarding PREFERRED VIEWING RANGES, or the amount of time the TCWF is viewed from any of the user-selected ranges. These include: 5, 15, 30, 50 (TRACON), 100 and 200 nm ranges. All MEM users reported 50 nm was the range of choice. Many ZME (4) users also preferred the 50 nm range. Three ZME users preferred the 100 nm range. None of the ZME users stated a preference for any range over 100 nm.

TABLE 23. PREFERRED TCWF RANGE VIEWING

USER GROUP	5 NM	15 NM	30 NM	50 NM	100 NM	200 NM
ALL USERS (N=16)	0	1	3	9	3	0
MEM Sups (N=5)	0	0	0	5	0	0
ZME TMCs (N=11)	0	1	3	4	3	0

Table 24 summarizes user responses regarding their need for a RANGE GREATER THAN 200 NM. Optimal ranges for eight ZME users were beyond 200 nm (from 400 to 600 nm). Three ZME users noted the current 200 nm range was adequate; whereas, one indicated that 100 nm would be the optimal range. One TRACON user preferred a range beyond 200 nm, however, the optimal range identified was an existing one.

TABLE 24. FREQUENCY OF RESPONSES - RANGE GREATER THAN 200 NM

USER GROUP	YES	OPTIMAL RANGES IN NM	NO
ALL USERS (N=16)	9	See Below.	7
MEM Sups (N=5)	1	a. 100-200	4
ZME TMCs (N=11)	8	a. 400 b. 100 c. 500 d. 600	3

ACCURACY SCORE PERCEPTIONS for both the 50 and 200 nm ranges were solicited. Users were asked if the accuracy scores at both of these ranges reflected the actual forecast performance of the TCWF. Tables 25 and 26 summarize these impressions. For both ranges, all MEM users and most ZME users reported the accuracy scores matched their impression of the TCWF performance during the forecast predicted.

TABLE 25 - DOES ACCURACY SCORE MATCH ACTUAL FORECAST - 50 NM

USER GROUP	YES	NO	N/A
ALL USERS (N=16)	15	0	1
MEM Sups (N=5)	5	0	0
ZME TMCs (N=11)	10	0	1

TABLE 26 - DOES ACCURACY SCORE MATCH ACTUAL FORECAST - 200 NM

USER GROUP	YES	NO	N/A
ALL USERS (N=16)	14	0	2
MEM Sups (N=5)	4	0	1
ZME TMCs (N=11)	10	0	1

6.3.3 Phase 1 Task Questions.

Questionnaire results summarizing TCWF, ITWS SEP, and CWSU utility for specific job tasks during convective weather are presented in tables 27 and 29. Users were asked not to compare the three information sources to each other, but to rank each one separately, as it applied to the task. Ranking results summarizing the frequency of use of the TCWF to complete the specific tasks listed are presented in tables 28 and 30.

Table 27 summarizes the UTILITY SCORES for MEM TRACON users. With the exception of the "change runway configuration" task, users considered the TCWF and the ITWS SEP component equally useful for all task areas. Users did indicate usefulness of CWSU information was borderline for determining departure and arrival flow rates. This may be a function of the limited interaction between MEM TRACON Sups and the ZME CWSU.

TABLE 27. MEDIAN UTILITY SCORE FOR FORECAST PRODUCTS (MEM TRACON ONLY)

TASKS	TCWF	ITWS SEP	CWSU
Change Runway Configuration	4.5	5	4
Determine When to Close Arrival Gates	5	5	5
Determine When to Close Departure Gates	5	5	5
Determine When to Reopen Departure Gates	5	5	5
Plan Departure Radials	5	5	5
Determine Departure Flow Rate	5	5	3.5
Determine Arrival Flow Rate	5	5	3.5
Coordinate SWAPs	4	4	4
Aid Situational Awareness	5	5	5

Note: 1 = Of No Use, 2 = Of Little Use, 3 = Borderline, 4 = Somewhat Useful, 5 = Extremely Useful, and N/A = Product not used for task.

Table 28 summarizes FREQUENCY OF USE of the TCWF to complete the specific MEM TRACON tasks during convective weather. MEM TRACON users utilized the TCWF at least 70% of the time for all identified tasks. Users also indicated that the TCWF was used over 90% of the time to aid situational awareness.

TABLE 28. MEDIAN FREQUENCY SCORE OF TCWF USE PER TASK (MEM TRACON ONLY)

TASKS	FREQUENCY
Change Runway Configuration	4
Determine When to Close Arrival Gates	4
Determine When to Close Departure Gates	4
Determine When to Reopen Departure Gates	4
Plan Departure Radials	4
Determine Departure Flow Rate	4
Determine Arrival Flow Rate	4
Coordinate SWAPs	4
Aid Situational Awareness	5

Note: 1 = Hardly Ever (less than 10%), 2 = Seldom (about 30%), 3 = Now and Then(about 50%), 4 = Frequently (about 70%), 5 = Almost Always (at least 90%), and N/A = Product not used for task.

Table 29 summarizes the UTILITY SCORES for ZME TMU users. ZME users ranked the TCWF as useful as the ITWS SEP forecast information for every task listed. For anticipating

Miles-In-Trail (MIT) restrictions, the TCWF was rated slightly higher than the ITWS SEP. ZME TMU users also rated the CWSU information as being useful for most tasks.

TABLE 29. MEDIAN UTILITY SCORE FOR FORECAST PRODUCTS (ZME ONLY)

TASKS	TCWF	ITWS SEP	CWSU
Plan Aircraft Re-Routes	4	4	4
Anticipate MIT Restrictions	4	3.5	4
Open/Close/Reconfigure Arrival Transition Areas (ATAs)	4	4	4
Open/Close/Reconfigure Departure Transition Areas (DTAs)	4	4	4
Determine Holding Areas	4	4	4
Anticipate Airport Closures	4	4	4
Coordinate Military Release Areas	2	2	2
Aid Situational Awareness	5	5	4.5

Note: 1 = Of No Use, 2 = Of Little Use, 3 = Borderline, 4 = Somewhat Useful, 5 = Extremely Useful, and N/A = Product not used for task.

Table 30 summarizes FREQUENCY OF USE of the TCWF to complete the specific ZME TMU tasks during convective weather. ZME users utilized the TCWF most frequently for aiding situational awareness. The TCWF was used at least 70% of the time to plan aircraft re-routes; to open, close, or reconfigure ATAs and DTAs; and to anticipate airport closures. Users indicated that the TCWF was used about 50% of the time or less to anticipate MIT restrictions and in determining holding areas. The less frequent TCWF use for anticipating MIT restrictions may be due to the longer range planning required for MIT implementation (more than the 60-minute forecast can provide). Also, based on ZME interview data, some users indicated the TCWF was beneficial in releasing planes from holding. However, determining holding areas was not reported and may be attributable to the less frequent use of the product for this task. Finally, the TCWF was used less than 10% of the time for coordinating military release areas. This result could be a function of the infrequency in which this task is performed.

TABLE 30. FREQUENCY SCORE FOR TCWF USE FOR EACH TASK (ZME ONLY)

TASKS	FREQUENCY
Plan Aircraft Re-Routes	4
Anticipate MIT Restrictions	3
Open/Close/Reconfigure ATAs	4
Open/Close/Reconfigure DTAs	4
Determine Holding Areas	2.5
Anticipate Airport Closures	4
Coordinate Military Release Areas	1
Aid Situational Awareness	5

Note: 1 = Hardly Ever (less than 10%), 2 = Seldom (about 30%), 3 = Now and Then (about 50%), 4 = Frequently (about 70%), 5 = Almost Always (at least 90%), and N/A = Product not used for task.

Users were asked if ACCURACY SCORES effected decisions to use or not use the TCWF. If affected, then criteria used for using/not using the product was solicited. Table 31 summarizes accuracy scoring and criteria overall, and for MEM TRACON and ZME individually. One MEM TRACON user reported looking at accuracy scores to determine product use. In this case, criteria for not using the product were scores ranging below 60%. Three ZME TMC users reported using accuracy scores to determine product use. Criteria identified for product non-use included accuracy ranges below 65% and 60%. Three ZME users indicated accuracy scores were not used.

TABLE 31. DECISION TO USE PRODUCT BASED ON ACCURACY SCORES

USER GROUP	YES	CRITERIA FOR NOT USING	NO	N/A
ALL USERS (N=12)	4	See Below	7	1
MEM Sups (N=5)	1	a. Below 60%	4	0
ZME TMCs (N=7)	3	a. Below 65% b. Below 60%	3	1

6.3.4 Phase 2 Task Questions.

Table 32 summarizes UTILITY SCORES for identified task areas for MEM TRACON users. Utility of CWSU information was not measured since this source is rarely used. MEM users considered the TCWF and the ITWS SEP component equally useful for all task areas. Both ITWS SEP and TCWF were ranked "somewhat useful" for most task areas. For "determining arrival flow rates" and "aiding situational awareness," both products were considered "extremely useful." Coordinating Severe Weather Avoidance Programs (SWAPs) was rated "borderline," or "of little use."

TABLE 32. MEDIAN UTILITY SCORE FOR FORECAST PRODUCTS (MEM TRACON ONLY)

TASKS	TCWF	ITWS SEP
Change Runway Configuration	4	4
Determine When to Close Arrival Gates	4	4
Determine When to Close Departure Gates	4	4
Determine When to Reopen Departure Gates	4	4
Plan Departure Radials	4	4
Determine Departure Flow Rate	4	4
Determine Arrival Flow Rate	5	5
Coordinate SWAPs	3	3
Aid Situational Awareness	5	5

Note: 1 = Of No Use, 2 = Of Little Use, 3 = Borderline, 4 = Somewhat Useful, 5 = Extremely Useful, and N/A = Product not used for task.

Table 33 summarizes FREQUENCY OF USE of the TCWF to complete the specific MEM TRACON tasks during convective weather. MEM TRACON users utilized the TCWF at least 70% of the time for the following tasks:

a. Change runway configuration,
b. Determine when to close arrival gates,
c. Determine when to close departure gates,
d. Determine when to reopen departure gates, and
e. Plan departure radials.

Users also indicated that the TCWF was used over 90% of the time to aid situational awareness.

For three task areas, the frequency of TCWF use was rated 50% or "now and then.". These tasks included:

a. Determine departure flow rate,
b. Determine arrival flow rate, and
c. Coordinate SWAPs

TABLE 33. MEDIAN FREQUENCY SCORE OF TCWF USE PER TASK (MEM TRACON ONLY)

TASKS	FREQUENCY
Change Runway Configuration	4
Determine When to Close Arrival Gates	4
Determine When to Close Departure Gates	4
Determine When to Reopen Departure Gates	4
Plan Departure Radials	4
Determine Departure Flow Rate	3
Determine Arrival Flow Rate	3
Coordinate SWAPs	3
Aid Situational Awareness	5

Note: 1 = Hardly Ever (less than 10%), 2 = Seldom (about 30%), 3 = Now and Then (about 50%), 4 = Frequently (about 70%), 5 = Almost Always (at least 90%), and N/A = Product not used for task.

Table 34 summarizes the UTILITY SCORES for ZME TMU users. ZME users ranked the TCWF as "extremely useful" for all but two task areas. For anticipating MIT and coordinating military release areas, the TCWF was rated "somewhat useful". ITWS SEP and CWSU were also rated as "somewhat useful" for these tasks. TCWF usefulness ratings were typically higher than usefulness rating scores for ITWS SEP and CWSU. ZME TMU users also rated the CWSU information as being useful for most tasks. Both TCWF and the CWSU were considered extremely useful in aiding situational awareness.

TABLE 34. MEDIAN UTILITY SCORE FOR FORECAST PRODUCTS (ZME ONLY)

TASKS	TCWF	ITWS SEP	CWSU
Plan Aircraft Re-Routes	5	4	4
Anticipate Miles-In-Trail (MIT) Restrictions	4	4	4
Open/Close/Reconfigure Arrival Transition Areas (ATAs)	5	4	5
Open/Close/Reconfigure Departure Transition Areas (DTAs)	5	4	4.5
Determine Holding Areas	5	4	4
Anticipate Airport Closures	5	4	4
Coordinate Military Release Areas	4	4	4
Aid Situational Awareness	5	4	5

Note: 1 = Of No Use, 2 = Of Little Use, 3 = Borderline, 4 = Somewhat Useful, 5 = Extremely Useful, and N/A = Product not used for task.

Table 35 summarizes FREQUENCY OF USE of the TCWF to complete the specific ZME TMU tasks during convective weather. ZME users utilized the TCWF most frequently for anticipating

airport closures. The TCWF was used at least 70% of the time to plan aircraft re-routes, to open, close, or reconfigure ATAs and DTAs, anticipate MIT restrictions, determine holding areas, and aid situational awareness. Users indicated that the TCWF was used about 50% of the time or less to coordinate military release areas. This result could be a function of the infrequency in which this task is performed.

TABLE 35. FREQUENCY SCORE FOR TCWF USE FOR EACH TASK (ZME ONLY)

TASKS	FREQUENCY
Plan Aircraft Re-Routes	4
Anticipate Miles-In-Trail Restrictions	4
Open/Close/Reconfigure ATAs	4
Open/Close/Reconfigure DTAs	4
Determine Holding Areas	4
Anticipate Airport Closures	5
Coordinate Military Release Areas	3
Aid Situational Awareness	4

Note: 1 = Hardly Ever (less than 10%), 2 = Seldom (about 30%), 3 = Now and Then (about 50%), 4 = Frequently (about 70%), 5 = Almost Always (at least 90%), and N/A = Product not used for task.

6.4 WORKLOAD.

As described in section 4.2.3, the MCH mental workload scale was used to measure overall perceived user mental workload as it applied to operational use of the TCWF display.
Figures 9 and 10 are bar charts of pre- and post-median ranking scores of the MCH workload analysis for MEM and ZME users. The 10-point workload scale rating definitions ranged from:

a. 1 - very easy, highly desirable. Operator mental effort is minimal and desired performance is easily attainable, to

b. 10 - Impossible. Instructed task cannot be accomplished reliably.

Lower rating scores indicated lower perceived workload in performance of any of the identified tasks during a convective weather event. Conversely, higher scores indicated greater perceived workload.

Comparisons between MEM TRACON users' MCH scale pre-and post-workload analysis showed that perceptions of operator mental workload significantly decreased after introduction of the TCWF product for all task areas.

For ZME users, however, workload did not globally decrease. For one of the six identified ZME tasks, anticipating airport closure, perceived operator workload actually increased with introduction of the TCWF.

For two task areas, perceived mental workload remained the same (did not increase or decrease with introduction of the TCWF). These included:

a. Anticipate MIT restrictions, and
b. Plan departure transition areas.

Post score comparisons for the remaining ZME tasks were lower, indicating workload had decreased somewhat after TCWF had been introduced. These tasks included:

a. Plan reroutes/deviations,
b. Plan arrival transition areas, and
c. Coordinate military release areas.

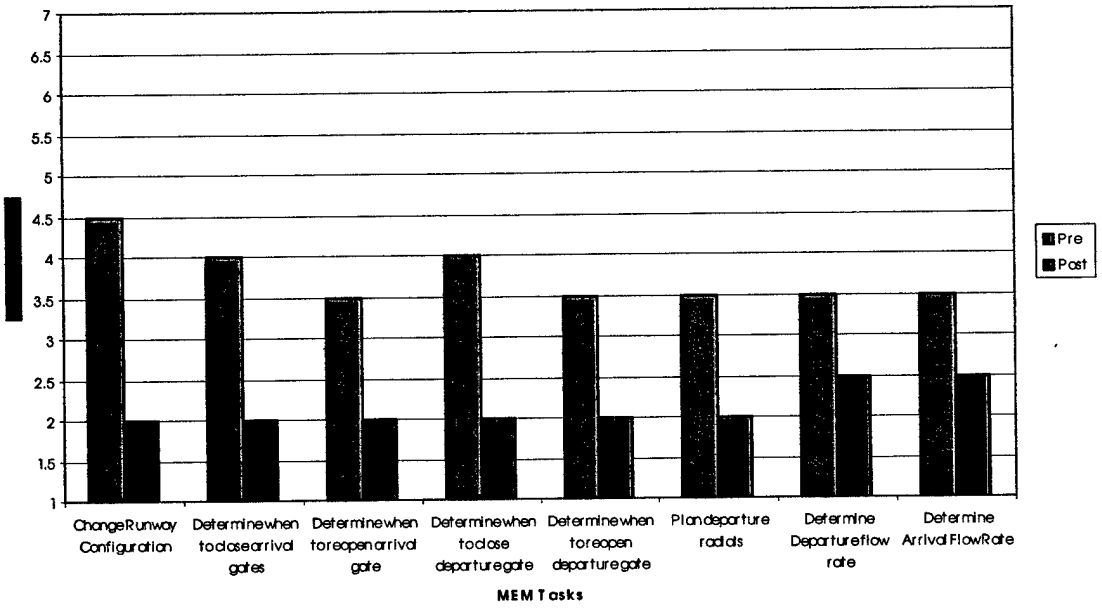

FIGURE 9. PRE-AND POST-MCH WORKLOAD COMPARISONS – MEM TRACON

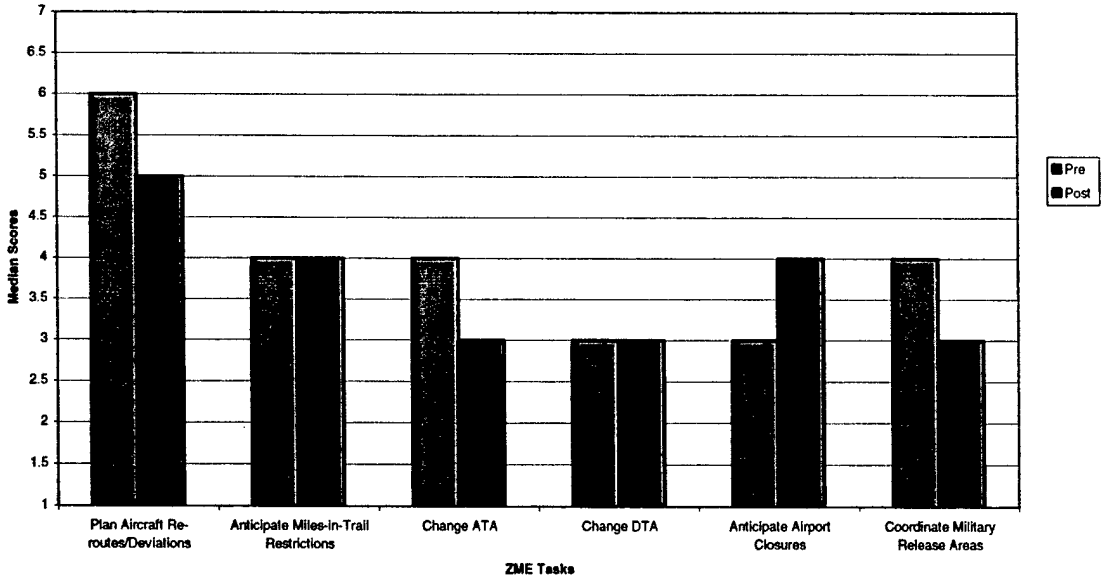

FIGURE 10. PRE-AND POST-MCH WORKLOAD COMPARISONS – ZME

7. CONCLUSIONS.

Unless noted, conclusions discussed in this section reflect results from both Phase 1 and Phase 2 of the TCWF 2000 Demonstration.

a. Overall TCWF Impression - Results indicated the Terminal Convective Weather Forecast (TCWF) was viewed favorably by almost all participants in terms of utility, task benefit, benefit beyond Integrated Terminal Weather System (ITWS), and interface characteristics. The overall impression of the product was positive.

b. MEM TRACON Task Benefit - All Memphis International Airport (MEM) Terminal Radar Approach Control (TRACON) users reported, in structured interview responses, that TCWF provided benefit in performing tasks during operationally significant convective events. This perception was also reflected in questionnaire responses where utility and frequency of TCWF use was measured. In Phase 1, TCWF was rated "extremely useful" for most task areas. Results for Phase 2 were slightly lower with most tasks receiving "somewhat useful" ratings. No task areas were rated "borderline" or negatively (i.e. no use). In Phase 1, frequency of TCWF use in all task areas was reported to be 70% of the time or more. For Phase 2, however, frequency of use reportedly decreased to "now and then" or around 50% of the time in three task areas:

1. Determine Departure Flow Rate,
2. Determine Arrival Flow Rate, and
3. Coordinate Severe Weather Avoidance Programs (SWAPs)

Why MEM TRACON users took a slightly less positive view of the TCWF after Phase 2 completion is unknown.

Recollections from MEM TRACON users (n=3) who recalled TCWF performance during convective events were positive overall. Of these, TCWF benefit was noted for determining when to come in or out of holding situations, planning runway changes, and anticipating gate impacts.

c. ZME TMU Task Benefit – Memphis ARTCC (ZME) Traffic Management Coordinator (TMCs') perceptions for tasks were mostly positive. Although found very useful for MEM airspace impacts, the TCWF was not adequate for all airspace requirements, which comprises a majority of ZME operations. From Phase 1, utility scores from the questionnaire show that the TCWF was found "somewhat useful" in all task areas with the exception of coordinating military release areas. ITWS and the Center Weather Service Unit (CWSU) were also considered "of little use" for this task. As noted in the results section of this report, coordinating military release areas is infrequently performed. From Phase 2, however, utility scores were somewhat higher. With the exception of "Determine MIT restrictions", and "Coordinate military release areas" (rated "somewhat useful") the TCWF was rated "extremely useful" for all remaining task areas.

TCWF utility was rated positively for most ZME tasks in Phase 1; however, the product was not used frequently for some of the identified task areas. These tasks included: anticipating miles-in-trail (MIT) restrictions, determining holding areas, and coordinating military release areas where frequency of use was rated at 50% or below.

ZME interview responses indicated the TCWF was useful in determining when to release aircraft from holding; however, using the TCWF to determine holding restrictions was not reported. As reported in the Results section, less frequent TCWF use for anticipating MIT restrictions may be attributed to the longer strategic planning required for determining MIT. Again, since the "coordinating military release areas" task is seldom performed, this may explain infrequency of TCWF use for this activity.

Phase 2 data revealed that frequency of use for determining holding areas and anticipating MIT restrictions increased to "almost always" or over 70% of the time. Although in Phase 1, utility ratings for both ITWS Storm Extrapolated Position (SEP) and the TCWF were almost identical, for Phase 2, TCWF utility scores were generally higher than those for ITWS. Users reportedly preferred the TCWF areal storm coverage and 60-minute animated forecast over the ITWS SEP 20-minute leading edge line depictions.

Many ZME users recalled TCWF performance during line-storm convective weather events. All recollections were positive, with TCWF reportedly aiding in decisions involving aircraft holding, flow control, MEM runway and gate impacts, as well as enhancing situational awareness.

d. Situational Awareness - Overall perceptions of the TCWF benefiting Situation Awareness (SA) were positive. Questionnaire responses from both ZME and MEM

TRACON users indicated the TCWF was extremely useful in aiding SA. This view was also reflected in interview responses where both ZME and MEM TRACON users noted heightened SA as one of the TCWF task benefits.

e. TCWF Interface Suitability - Almost all TCWF interface components (e.g., display window, forecast accuracy scores) were viewed favorably overall (both ZME and MEM TRACON users) on the dimensions of utility, readability, and ease of use. [All components were rated positively (moderately suitable to totally suitable). Most components were rated totally suitable.] There were no significant differences between median ranking scores from ZME and MEM TRACON users.

f. TCWF Suggested Improvements - Users indicated some areas for TCWF improvement. MEM TRACON users suggested the following:

1. Keep the TCWF separate from ITWS - See item i (below).

2. Include gust front and wind information - Including this information would benefit decision-making regarding changing and opening/closing runways.

3. Integrate with ITWS - See item i (below).

4. Improve TCWF training - Some users indicated that more comprehensive training might have lead to more frequent TCWF use.

5. Weather intensity level colors should be the same as those used on ITWS. The variations of the color yellow to imply moderate to high forecast weather intensity were confusing to some users. Using the standard color intensities displayed on the ITWS Situation Display was suggested.

ZME users suggested:

1. Improve growth and decay capability - Show where cells are building and when and where they will dissipate. Clearly indicate where weather will be and when.

2. Improve forecast accuracy - One ZME user noted that the TCWF was not relied on during air-mass type convection. Another reported little confidence in TCWF accuracy overall and did not use the product.

3. Integrate with ITWS. See item i (below).

4. Keep TCWF separate from ITWS. See item i (below).

5. Include a ZME boundary map overlay - This overlay would delineate ZME airspace boundaries and would aid in locating areas of convection that may affect ZME airspace.

6. Increase product range to include all ZME airspace - Forecast weather requirements for ZME go beyond the MEM Terminal area. Viewing all ZME airspace may contribute to planning and decision-making for enroute as well as terminal air traffic.

7. Larger display monitor - A larger display should enhance readability of TCWF graphics and text.

8. Extend past weather depictions - Past history animations longer than 30 minutes would enhance weather trending perceptions.

g. Forecast Requirements - Almost all MEM TRACON users were satisfied with the existing 30- and 60-minute predictions.

Although some ZME users wanted a 90-minute forecast, most found the existing 30 and 60-minute forecasts adequate. In order to effectively control all air traffic within ZME airspace during convective weather occurrences, TMCs require planning time beyond the 60-minute forecast provided by the TCWF. However, many ZME users reported only using the TCWF for MEM airport impacts. Therefore, the TCWF appears to be more of a tactical tool for decisions regarding MEM arrivals and departures and less of a strategic tool for longer range enroute planning.

h. Range Requirements - Given the available ranges, MEM TRACON users preferred the 50 nautical mile (nm) (TRACON) range presentation. Consideration of a range beyond 200 nm was unnecessary since 50 nm generally encompassed the MEM area of interest.

Most ZME users viewed the 30 and 50 nm ranges. However, many indicated a range beyond 200 nm would be optimal. Optimal distances ranged from 400 to 600 nm. Although this preference was based on total ZME airspace coverage, results showed that the existing 200 nm range was seldom used. Therefore it is questionable if longer-range depictions would be of use to the typical ZME user.

i. Benefit Beyond ITWS - Most users reported additional benefit to having TCWF as well as ITWS since the TCWF provides a better visual presentation, a longer forecast, and better indication of storm movement. Although users would like to have the TCWF along with ITWS, some users indicated that the display should be separate from and not integrated with the existing ITWS display. Product integration may be confusing and inhibit TCWF/ITWS accessibility. Testing of an integrated TCWF/ITWS should be considered before implementation of the two products on one display.

j. Forecast Accuracy Scores - All users from both MEM and ZME, who responded to the question of whether the accuracy scores reflected the actual accuracy of the TCWF, indicated that the scores had approximated their perception of the product's forecasting performance.

Results on whether the accuracy scores affected decisions on product use are mixed. In Phase 1, almost all MEM TRACON users reported no reliance on these scores for basing use/non-use decisions. The majority of ZME users, however, did factor in these scores before using TCWF information. Although currently unknown, this result could reflect individual preferences or perceptual differences between Air Route Traffic Control Center (ARTCC) and TRACON users.

Phase 2 results showed a slight increase in reliance on accuracy scores for both MEM and ZME users. It may be concluded, that with greater familiarity and confidence in accuracy score depictions, use of this feature may have increased.

k. Training - According to some MEM TRACON Supervisors, TCWF training should have been more intensive. With better training, the TCWF may have been more fully utilized.

Additionally, as discussed in the "Factors Affecting Results" section of this report, training material should not have contained only positive (or any) results from past TCWF Demonstrations. User bias in favor of a product or system may have confounded demonstration results.

l. Workload - Modified Cooper Harper (MCH) workload analysis revealed that for MEM TRACON users, perceived operator mental workload decreased significantly in all identified task areas after introduction of the TCWF.

Workload for ZME users, however, did not globally decrease. Workload was seen to increase for the task area of anticipating airport closure. For two other tasks areas: 1) Anticipate MIT restrictions, and 2) Plan departure transition areas; perceived operator mental workload remained the same. For the three remaining task areas measured, workload had decreased somewhat. Given these results, it is difficult to generalize the affect TCWF had on workload. It may be concluded that for ZME users, the TCWF had little impact (either positively or negatively) on perceived mental workload.

8. RECOMMENDATIONS.

Based on conclusions derived from this report, the following recommendations are proposed.

a. Integrated TCWF/ITWS Product Testing - Due to the absence of formal test requirements, ACB-630 cannot make recommendations for the operational use of the Terminal Convective Weather Forecast (TCWF). However, if implementation of the TCWF into Integrated Terminal Weather System (ITWS) proceeds as proposed, user evaluations should be conducted prior to operational availability of this new system. Even if ITWS and TCWF individually are deemed operationally suitable, combining the two creates a completely new system. Feedback from users was mixed concerning integration. Users expressed concern over combining the two systems on one platform. These concerns included but were not limited to: display clutter, individual product accessibility, confusion between the two product displays, and adequate display window space for a viewable product presentation.

It is probable that other issues may arise. Evaluation/testing should facilitate identification and resolution of these issues.

b. Training - Some users noted the TCWF might have been under-utilized because training was insufficient. It is recommended that in future demonstrations, subsequent to initial product training, some follow-up, such as revisiting the site and demonstrating all product capabilities during an operationally significant weather event, be initiated. This would reinforce previous training as well as demonstrate optimal product utilization.

It is also recommended that training material focus only on applications and use of the product and not as an opportunity for product promotion. This is especially critical if the product (in this case, TCWF) is to undergo an unbiased evaluation.

c. Algorithm improvement - It is recommended developers continue to focus research on improving the TCWF forecast accuracy, especially for air-mass convective weather.

9. ACRONYMS.

ARTCC	Air Route Traffic Control Center
ASD	Aircraft Situation Display
ASR	Airport Surveillance Radar
ATA	Arrival Transition Area
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
ATIS	Automatic Information Server
AWRP	Aviation Weather Research Program
CWSU	Center Weather Service Unit
DFW	Dallas/Ft. Worth International Airport
DTA	Departure Transition Area
GUI	Graphical User Interface
ITWS	Integrated Terminal Weather System
km	kilometer
MCH	Modified Cooper Harper
MCO	Orlando International Airport
MEM	Memphis International Airport
MIT	Miles-in-trail
MIT/LL	Massachusetts Institute of Technology/Lincoln Labs
NEXRAD	Next Generation Radar
nm	nautical mile
P3I	Pre-planned Product Improvement
SA	Situational Awareness
SD	Situation Display
SEP	Storm Extrapolated Position
Sup	Supervisor

SWAP	Severe Weather Avoidance Program
TCWF	Terminal Convective Weather Forecast
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control
WARP	Weather and Radar Processor
ZJX	Jacksonville ARTCC
ZME	Memphis ARTCC

APPENDIX A

TRACON AND ARTCC QUESTIONNAIRES

2000 TERMINAL CONVECTIVE WEATHER FORECAST DEMONSTRATION
Phase 1

MEMPHIS TRACON Supervisor/TMC QUESTIONNAIRE

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Instructions

The purpose of this questionnaire is to obtain feedback from users regarding the Terminal Convective Weather Forecast.

Feedback from users is a very important component of the Federal Aviation Administration (FAA) William J. Hughes Technical Center and the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) demonstration of the Terminal Convective Weather Forecast. Your responses to this questionnaire will provide important information for use in future iterations of the Terminal Convective Weather Forecast. Therefore, please respond to all questions as honestly and thoroughly as possible.

Responses to this questionnaire will remain ANONYMOUS and CONFIDENTIAL. A report will be written on the results of this questionnaire, summarizing respondents' comments; however no one will be identified or associated with any specific comment. **Please return the questionnaire to FAA Technical Center Evaluator.**

Definition of Terms

Utility - This refers to how useful the TCWF is in completing job tasks related to traffic planning as impacted by convective weather. Elements of utility would include: 1) effect on situational awareness; 2) impacts on decision making; and/or 3) impacts on workload.

Ease of Use - This refers to how easy the TCWF is to use in completing job tasks (i.e. navigation, button use). For example, a user may consider a feature easy to use if he/she can discriminate display characters and symbols.

Readability - This refers to the extent the information displayed is easy to see, readable, meaningful, and understandable. For example, overlaid text may be too small to read or obscured by other overlays.

Situational Awareness - Situational Awareness, or SA, has been defined as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future. Essentially, it is how one perceives and understands elements in the present situation and uses this information to anticipate future events.

Terminal Convective Weather Forecast Information/Feature Definitions

1. **Display Window (Past/Forecast Weather) -** The display window is the region in the center of the screen on which the past weather and forecast weather are displayed. The window can display from 30 minutes of past weather to 60 minutes of forecasted weather.

2. **Forecast Accuracy Score –** The Forecast Accuracy Score provides real-time scoring information for both the 30 and 60-minute forecasts.

3. **Forecast Weather Color Scale –** The forecast weather scale shows regions in which the growth and decay tracker expects a moderate to high probability that level 3 weather (yellow on ITWS) will occur during the forecast time interval. Solid yellow is used for high probability regions while a hatched yellow/gray is used for moderate probability regions.

Terminal Convective Weather Forecast Information/Feature Definitions (Cont'd)

4. **Movie Loop** - The movie loop selections allow the user to select a variety of movie loops for displaying data. Loops range from past weather only to 30 or 60-minute forecasts. Past weather and forecasted weather can be looped together in 10-minute increments. Looping can occur with or without past weather.

5. **Range Indicator** – The Range Indicator is located to the left of the display window just below the time display. The range indicator shows which range is currently selected (i.e., 50 NM or 200 NM).

6. **Relative Time Display** – This indicates relative time, or the time difference from the current time to the time of the weather shown in the display window. This time will be positive for the forecast images, and negative for past weather images. The font will be white when the images are looping and will turn red when the loop has been stopped.

7. **Start/Stop Loop Control** – The start/stop loop control function controls the starting and stopping of forecast loops. It also enables the user to display static forecast images.

Product/Feature Utility, Ease of Use, and Readability

Instructions: The five-point scale below should be used to rate the ease of use and readability of the Terminal Convective Weather Forecast. Please refer to these definitions when responding. Please rate the product/feature by circling the appropriate number.

Rating Scale Definitions

5 – Totally Suitable. This response indicates the product/feature being rated is totally appropriate to support TRACON Supervisors in the performance of their job tasks.

4 – Moderately Suitable. This response indicates the product/feature being rated is suitable with minimal negative impact and supports TRACON Supervisors in the performance of their job tasks.

3 – Suitable with Modification. This response indicates the product/feature being rated will be appropriate to support TRACON Supervisors in the performance of their job tasks; however, modifications would improve the product.

2 – Moderately Unsuitable. This response indicates the product/feature being rated requires some significant change to provide appropriate support to TRACON Supervisors in the performance of their job tasks.

1 – Totally Unsuitable. This response indicates the product/feature being rated will have a significant negative impact to TRACON Supervisors and will not support TMU job tasks.

NA - You have never used the product/feature in question.

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
1. Display Window (Forecast Weather)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
2. Relative Forecast Time Display						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
3. Range Indicators						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
4. Forecast Weather Color Scale						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
5. Movie Loop						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
6. Start/Stop Loop Control						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
7. Forecast Accuracy Score						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
8. Overlays (i.e. jet ways, roads)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
9. Windowing Options						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
10. Status Indicators						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA

Utility Per Job Task

Instructions: The five-point scale below should be used to rate how useful the Terminal Convective Weather Forecast (TCWF), the ITWS Storm Extrapolated Position (SEP), and CWSU Forecast Information were in performing each of the specified tasks during convective weather. Please rate the aforementioned products INDEPENDENT of each other. For example, both the TCWF and the ITWS SEP can receive "Extremely Useful" ratings for a specific task if appropriate. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Extremely Useful. This response indicates the convective weather forecast information had a significant positive effect on decisions related to the specified job task.

4 – Somewhat Useful. This response indicates the convective weather forecast information had some positive effect on decisions related to the specific job task.

3 – Borderline. This response indicates the convective weather forecast information had little to no effect on decisions related to the specific job task.

2 – Of Little Use. This response indicates the convective weather forecast information had some negative effect on decisions related to the specific job task.

1 – Of No Use. This response indicates the convective weather forecast information had a significant negative effect on decisions related to the specific job task.

NA - You have never used the product in question.

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
11. Change Runway Configuration						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
12. Determine When to Close Arrival Gate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
13. Determine When to Close Departure Gate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
14. Determine When to Reopen Departure Gate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
15. Plan Departure Radials						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
16. Determine Departure Flow Rate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
17. Determine Arrival Flow Rate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
18. Coordinate SWAPs						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
19. Aid Situational Awareness						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
20. Other _____						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Frequency of Use

Instructions: The five-point scale below should be used to rate the frequency (on average) in which the Terminal Convective Weather Forecast was used in performing the specific tasks listed. Please provide frequency ratings for TCWF use during CONVECTIVE WEATHER EVENTS only. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Almost Always. This response indicates the TCWF was used at least 90% of the time when performing the specified task during convective weather events.

4 – Frequently. This response indicates the TCWF was used about 70% of the time when performing the specified task during convective weather events.

3 – Now and Then. This response indicates the TCWF was used about 50% of the time when performing the specified task during convective weather events.

2 – Seldom. This response indicates the TCWF was used about 30% of the time when performing the specified task during convective weather events.

1 – Hardly Ever. This response indicates the TCWF was used less than 10% of the time when performing the specified task during convective weather events.

NA - You have never used the TCWF operationally during convective weather.

Select Job Tasks	Almost Always		Frequently	Now and Then	Seldom	Hardly Ever	
21. Change Runway Configuration	5	4	3	2	1	NA	
22. Determine When to Close Arrival Gate	5	4	3	2	1	NA	
23. Determine When to Close Departure Gate	5	4	3	2	1	NA	
24. Determine When to Reopen Departure Gate	5	4	3	2	1	NA	
25. Plan Departure Radials	5	4	3	2	1	NA	
26. Determine Departure Flow Rate	5	4	3	2	1	NA	
27. Determine Arrival Flow Rate	5	4	3	2	1	NA	
28. Coordinate SWAPs	5	4	3	2	1	NA	
29. Aid Situational Awareness	5	4	3	2	1	NA	
30. Other _____	5	4	3	2	1	NA	

31. Given the types of decisions that you make, what length of forecast time is most desired? (Circle one)

30 min. 60 min. 90 min. 120 min. Other _____min.

Why?_____

_____

32. What percentage of time did you view weather from the 50 NM range versus the 200 NM range?

50 NM %_____ 200 NM % _____

33. Would a range beyond 200 nautical miles be useful? (Circle one)

Yes No

Specify optimal range. Please explain.

_____

_____

34. Did the forecast accuracy score match your impression of the actual forecast accuracy? (Circle one)

Yes No

If No, which of the following is true: (mark one)

_____ actual forecast was better than the forecast accuracy score

_____ actual forecast was worse than the forecast accuracy score

35. Did the 30 and 60-minute accuracy scores effect your decision to use or not use the TCWF? (Circle one)

Yes No

If yes, how did it effect your decision? What were your scoring criteria for using/not using the TCWF product?

_____

_____

THANK YOU FOR YOUR TIME, EFFORT, AND COOPERATION

If you are unable to return this questionnaire to an on-site FAA Technical Center Evaluator, please mail the completed questionnaire to the address below.

Cynthia Fidalgo, Raytheon Technical Services Co.
Weather Branch, ACB-630
FAA Technical Center
Atlantic City International Airport, NJ 08405

2000 TERMINAL CONVECTIVE WEATHER FORECAST DEMONSTRATION

Phase 1

MEMPHIS CENTER TMU QUESTIONNAIRE

Prepared by:
Communication/Navigation/Surveillance
Engineering and Test Division, Weather Branch, ACB-630
William J. Hughes Technical Center
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

Instructions

The purpose of this questionnaire is to obtain feedback from users regarding the Terminal Convective Weather Forecast.

Feedback from users is a very important component of the Federal Aviation Administration (FAA) William J. Hughes Technical Center and the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) demonstration of the Terminal Convective Weather Forecast. Your responses to this questionnaire will provide important information for use in future iterations of the Terminal Convective Weather Forecast. Therefore, please respond to all questions as honestly and thoroughly as possible.

Responses to this questionnaire will remain ANONYMOUS and CONFIDENTIAL. A report will be written on the results of this questionnaire, summarizing respondents' comments; however no one will be identified or associated with any specific comment. **Please return the questionnaire to FAA Technical Center Evaluator.**

Definition of Terms

Utility - This refers to how useful the TCWF is in completing job tasks related to traffic planning as impacted by convective weather. Elements of utility would include: 1) effect on situational awareness; 2) impacts on decision making; and/or 3) impacts on workload.

Ease of Use - This refers to how easy the TCWF is to use in completing job tasks (i.e. navigation, button use). For example, a user may consider a feature easy to use if he/she can discriminate display characters and symbols.

Readability - This refers to the extent the information displayed is easy to see, readable, meaningful, and understandable. For example, overlaid text may be too small to read or obscured by other overlays.

Situational Awareness - Situational Awareness, or SA, has been defined as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future. Essentially, it is how one perceives and understands elements in the present situation and uses this information to anticipate future events.

Terminal Convective Weather Forecast Information/Feature Definitions

1. **Display Window (Past/Forecast Weather) -** The display window is the region in the center of the screen on which the past weather and forecast weather are displayed. The window can display from 30 minutes of past weather to 60 minutes of forecasted weather.

2. **Forecast Accuracy Score –** The Forecast Accuracy Score provides real-time scoring information for both the 30 and 60-minute forecasts.

3. **Forecast Weather Color Scale –** The forecast weather scale shows regions in which the growth and decay tracker expects a moderate to high probability that level 3 weather (yellow on ITWS) will occur during the forecast time interval. Solid yellow is used for high probability regions while a hatched yellow/gray is used for moderate probability regions.

Terminal Convective Weather Forecast Information/Feature Definitions (Cont'd)

4. **Movie Loop -** The movie loop selections allow the user to select a variety of movie loops for displaying data. Loops range from past weather only to 30 or 60-minute forecasts. Past weather and forecasted weather can be looped together in 10-minute increments. Looping can occur with or without past weather.

5. **Range Indicator –** The Range Indicator is located to the left of the display window just below the time display. The range indicator shows which range is currently selected (i.e., 50 NM or 200 NM).

6. **Relative Time Display** – This indicates relative time, or the time difference from the current time to the time of the weather shown in the display window. This time will be positive for the forecast images, and negative for past weather images. The font will be white when the images are looping and will turn red when the loop has been stopped.

7. **Start/Stop Loop Control** – The start/stop loop control function controls the starting and stopping of forecast loops. It also enables the user to display static forecast images.

Product/Feature Utility, Ease of Use, and Readability

Instructions: The five-point scale below should be used to rate the ease of use and readability of the Terminal Convective Weather Forecast. Please refer to these definitions when responding. Please rate the product/feature by circling the appropriate number.

Rating Scale Definitions

5 – Totally Suitable. This response indicates the product/feature being rated is totally appropriate to support ARTCC Traffic Management Coordinators in the performance of their job tasks.

4 – Moderately Suitable. This response indicates the product/feature being rated is suitable with minimal negative impact and supports ARTCC Traffic Management Coordinators in the performance of their job tasks.

3 – Suitable with Modification. This response indicates the product/feature being rated will be appropriate to support ARTCC Traffic Management Coordinators in the performance of their job tasks; however, modifications would improve the product.

2 – Moderately Unsuitable. This response indicates the product/feature being rated requires some significant change to provide appropriate support to ARTCC Traffic Management Coordinators in the performance of their job tasks.

1 – Totally Unsuitable. This response indicates the product/feature being rated will have a significant negative impact to ARTCC Traffic Management Coordinators and will not support TMU job tasks.

NA - You have never used the product/feature in question.

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
1. Display Window (Forecast Weather)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
2. Relative Forecast Time Display						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
3. Range Indicators						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
4. Forecast Weather Color Scale						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
5. Movie Loop						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
6. Start/Stop Loop Control						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
7. Forecast Accuracy Score						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
8. Overlays (i.e. jetways, roads)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
9. Windowing Options						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
10. Status Indicators						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA

Utility Per Job Task

Instructions: The five-point scale below should be used to rate how useful the Terminal Convective Weather Forecast (TCWF), the ITWS Storm Extrapolated Position (SEP), and CWSU Forecast Information were in performing each of the specified tasks during convective weather. Please rate the aforementioned products INDEPENDENT of each other. For example, both the TCWF and the ITWS SEP can receive "Extremely Useful" ratings for a specific task if appropriate. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Extremely Useful. This response indicates the convective weather forecast information had a significant positive effect on decisions related to the specified job task.

4 – Somewhat Useful. This response indicates the convective weather forecast information had some positive effect on decisions related to the specific job task.

3 – Borderline. This response indicates the convective weather forecast information had little to no effect on decisions related to the specific job task.

2 – Of Little Use. This response indicates the convective weather forecast information had some negative effect on decisions related to the specific job task.

1 – Of No Use. This response indicates the convective weather forecast information had a significant negative effect on decisions related to the specific job task.

NA - You have never used the product in question.

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
11. Plan Aircraft Re-routes/Deviations						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
12. Anticipate Miles-In-Trail Restrictions						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
13. Open/Close/Reconfigure Arrival Transition Areas (ATA)						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
14. Open/Close/Reconfigure Departure Transition Areas (DTA)						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
15. Determine Holding Areas						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
16. Anticipate Airport Closures						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
17. Coordinate Military Release Areas						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
18. Aid Situational Awareness						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
19. Other _____						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Frequency of Use

Instructions: The five-point scale below should be used to rate the frequency (on average) in which the Terminal Convective Weather Forecast was used in performing the specific tasks listed. Please provide frequency ratings for TCWF use during CONVECTIVE WEATHER EVENTS only. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Almost Always. This response indicates the TCWF was used at least 90% of the time when performing the specified task during convective weather events.

4 – Frequently. This response indicates the TCWF was used about 70% of the time when performing the specified task during convective weather events.

3 – Now and Then. This response indicates the TCWF was used about 50% of the time when performing the specified task during convective weather events.

2 – Seldom. This response indicates the TCWF was used about 30% of the time when performing the specified task during convective weather events.

1 – Hardly Ever. This response indicates the TCWF was used less than 10% of the time when performing the specified task during convective weather events.

NA - You have never used the TCWF operationally during convective weather.

Select Job Tasks	Almost Always	Frequently	Now and Then	Seldom	Hardly Ever	
20. Plan Aircraft Re-routes/Deviations	5	4	3	2	1	NA
21. Anticipate Miles-In-Trail Restrictions	5	4	3	2	1	NA
22. Open/Close/Reconfigure ATAs	5	4	3	2	1	NA
23. Open/Close/Reconfigure DTAs	5	4	3	2	1	NA
24. Determine Holding Areas	5	4	3	2	1	NA
25. Anticipate Airport Closures	5	4	3	2	1	NA
26. Coordinate Military Release Areas	5	4	3	2	1	NA
27. Aid Situational Awareness	5	4	3	2	1	NA
28. Other _____	5	4	3	2	1	NA

29. Given the types of decisions that you make, what length of forecast time is most desired? (circle one)

30 min. 60 min. 90 min. 120 min. Other _____min.

Why?_____

_____

30. What percentage of time did you view weather from the 50 NM range versus the 200 NM range?

50 NM %_____ 200 NM % _____

31. Would a range beyond 200 nautical miles be useful? (circle one)

Yes No

Specify optimal range. Please explain.

_____

_____

32. Did the forecast accuracy score match your impression of the actual forecast accuracy? (circle one)

Yes No

If No, which of the following is true: (mark one)

_____ actual forecast was better than the forecast accuracy score

_____ actual forecast was worse than the forecast accuracy score

33. Did the 30 and 60-minute accuracy scores effect your decision to use or not use the TCWF? (circle one)

Yes No

If yes, how did it effect your decision? What were your scoring criteria for using/not using the TCWF product?

_____

_____

THANK YOU FOR YOUR TIME, EFFORT, AND COOPERATION

If you are unable to return this questionnaire to an on-site FAA Technical Center Evaluator, please mail the completed questionnaire to the address below.

Cynthia Fidalgo, Raytheon Technical Services Co.
Weather Branch, ACB-630
FAA Technical Center
Atlantic City International Airport, NJ 08405

2000 TERMINAL CONVECTIVE WEATHER FORECAST DEMONSTRATION

Phase 2

MEMPHIS TERMINAL RADAR CONTROL (TRACON)/TOWER SUPERVISOR QUESTIONNAIRE

Prepared by:
Communication/Navigation/Surveillance
Engineering and Test Division, Weather Branch, ACB-630
William J. Hughes Technical Center
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

Instructions

The purpose of this questionnaire is to obtain feedback from users regarding the Terminal Convective Weather Forecast.

Feedback from users is a very important component of the Federal Aviation Administration (FAA) William J. Hughes Technical Center and the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) demonstration of the Terminal Convective Weather Forecast. Your responses to this questionnaire will provide important information for use in future iterations of the Terminal Convective Weather Forecast. Therefore, please respond to all questions as honestly and thoroughly as possible.

Responses to this questionnaire will remain ANONYMOUS and CONFIDENTIAL. A report will be written on the results of this questionnaire, summarizing respondents' comments; however no one will be identified or associated with any specific comment. **Please return the questionnaire to FAA the Technical Center Evaluator.**

Definition of Terms

Utility - This refers to how useful the TCWF is in completing job tasks related to traffic planning as impacted by convective weather. Elements of utility would include: 1) effect on situational awareness; 2) impacts on decision making; and/or 3) impacts on workload.

Ease of Use - This refers to how easy the TCWF is to use in completing job tasks (i.e. navigation, button use). For example, a user may consider a feature easy to use if he/she can discriminate display characters and symbols.

Readability - This refers to the extent the information displayed is easy to see, readable, meaningful, and understandable. For example, overlaid text may be too small to read or obscured by other overlays.

Situational Awareness - Situational Awareness, or SA, has been defined as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future. Essentially, it is how one perceives and understands elements in the present situation and uses this information to anticipate future events.

Terminal Convective Weather Forecast Information/Feature Definitions

1. **Display Window (Past/Forecast Weather) -** The display window is the region where the past weather and forecast weather are displayed. The window can display from 30 minutes of past weather to 60 minutes of forecasted weather.

2. **Forecast Accuracy Score –** The Forecast Accuracy Score provides real-time scoring information for both the 30 and 60-minute forecasts at TRACON and 200 nm ranges.

3. **Forecast Weather Color Scale –** The forecast weather scale shows regions in which the growth and decay tracker expects a moderate to high probability that level 3 weather (yellow on ITWS) will occur during the forecast time interval. Solid yellow is used for high probability regions while a hatched yellow/gray is used for moderate probability regions.

4. **Movie Loop** - The movie loop selections allow the user to select a variety of movie loops for displaying data. Loops range from past weather only to 30 or 60-minute forecasts. Past weather and forecasted weather can be looped together in 10-minute increments. Looping can occur with or without past weather.

5. **Relative Time Display** – The relative time display is located on the bottom left of the display screen. This display indicates relative time, or the time difference from the current time to the time of the weather shown in the display window. This time will be positive for the forecast images, and negative for past weather images. The font will be white when the images are looping and will turn red when the loop has been stopped.

6. **Start/Stop Loop Control** – The start/stop loop control function controls the starting and stopping of forecast loops. It also enables the user to display static forecast images.

7. **Overlays** - Overlays are accessed via the overlay menu and are user selected. Overlays consist of: jetways, victorways range rings, TRACON, outlying airports, counties, MEM sector, and states.

8. **Product Status Buttons** - Product status buttons are located on the status bar on the upper left side of the display. The buttons will be red if any product represented by the button is not available for Memphis airport in the display window. Green indicates product availability.

Product/Feature Utility, Ease of Use, and Readability

Instructions: The five-point scale below should be used to rate the ease of use and readability of the Terminal Convective Weather Forecast. Please refer to these definitions when responding. Please rate the product/feature by circling the appropriate number.

Rating Scale Definitions

5 – Totally Suitable. This response indicates the product/feature being rated is totally appropriate to support ARTCC Traffic Management Coordinators in the performance of their job tasks.

4 – Moderately Suitable. This response indicates the product/feature being rated is suitable with minimal negative impact and supports ARTCC Traffic Management Coordinators in the performance of their job tasks.

3 – Suitable with Modification. This response indicates the product/feature being rated is appropriate to support ARTCC Traffic Management Coordinators in the performance of their job tasks; however, modifications would improve the product.

2 – Moderately Unsuitable. This response indicates the product/feature being rated requires some significant change to provide appropriate support to ARTCC Traffic Management Coordinators in the performance of their job tasks.

1 – Totally Unsuitable. This response indicates the product/feature being rated has a significant negative impact to ARTCC Traffic Management Coordinators and will not support TMU job tasks.

NA - You have never used the product/feature in question.

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
1. Display Window (Forecast Weather)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
2. Relative Forecast Time Display						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
3. Forecast Weather Color Scale						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
4. Movie Loop						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
5. Start/Stop Loop Control						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
6. Forecast Accuracy Score						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
7. Overlays (i.e. jetways, roads)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
8. Windowing Options						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
9. Status Indicators						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA

Utility Per Job Task

Instructions: The five-point scale below should be used to rate how useful the Terminal Convective Weather Forecast (TCWF), the ITWS Storm Extrapolated Position (SEP), and CWSU Forecast Information were in performing each of the specified tasks during convective weather. Please rate the aforementioned products INDEPENDENT of each other. For example, both the TCWF and the ITWS SEP can receive "Extremely Useful" ratings for a specific task if appropriate. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Extremely Useful. This response indicates the convective weather forecast information had a significant positive effect on decisions related to the specified job task.

4 – Somewhat Useful. This response indicates the convective weather forecast information had some positive effect on decisions related to the specific job task.

3 – Borderline. This response indicates the convective weather forecast information had little to no effect on decisions related to the specific job task.

2 – Of Little Use. This response indicates the convective weather forecast information had some negative effect on decisions related to the specific job task.

1 – Of No Use. This response indicates the convective weather forecast information had a significant negative effect on decisions related to the specific job task.

NA - You have never used the product in question.

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
10. Change Runway Configuration						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
11. Determine When to Close Arrival Gate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
12. Determine When to Close Departure Gate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
13. Determine When to Reopen Departure Gate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
14. Plan Departure Radials						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
15. Determine Departure Flow Rate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
16. Determine Arrival Flow Rate						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
17. Coordinate SWAPs						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
18. Aid Situational Awareness						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
19. Other _____						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Frequency of Use

Instructions: The five-point scale below should be used to rate the frequency (on average) in which the Terminal Convective Weather Forecast was used in performing the specific tasks listed. Please provide frequency ratings for TCWF use during CONVECTIVE WEATHER EVENTS only. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Almost Always. This response indicates the TCWF was used at least 90% of the time when performing the specified task during convective weather events.

4 – Frequently. This response indicates the TCWF was used about 70% of the time when performing the specified task during convective weather events.

3 – Now and Then. This response indicates the TCWF was used about 50% of the time when performing the specified task during convective weather events.

2 – Seldom. This response indicates the TCWF was used about 30% of the time when performing the specified task during convective weather events.

1 – Hardly Ever. This response indicates the TCWF was used less than 10% of the time when performing the specified task during convective weather events.

NA - You have never used the TCWF operationally during convective weather.

Select Job Tasks	Almost Always	Frequently	Now and Then	Seldom	Hardly Ever	
20. Change Runway Configuration	5	4	3	2	1	NA
21. Determine When to Close Arrival Gate	5	4	3	2	1	NA
22. Determine When to Close Departure Gate	5	4	3	2	1	NA
23. Determine When to Reopen Departure Gate	5	4	3	2	1	NA
24. Plan Departure Radials	5	4	3	2	1	NA
25. Determine Departure Flow Rate	5	4	3	2	1	NA
26. Determine Arrival Flow Rate	5	4	3	2	1	NA
27. Coordinate SWAPs	5	4	3	2	1	NA
28. Aid Situational Awareness	5	4	3	2	1	NA
29. Other _____	5	4	3	2	1	NA

30. Given the types of decisions that you make, what length of forecast time is most desired? (circle one)

30 min. 60 min. 90 min. 120 min. Other _____min.

Why?_____

_____

31. What nautical mile range(s) do you use most often?

5 mi___ 15 mi___ 30 mi ____ TRACON_____ 100 mi____ 200 mi____

32. Would a range beyond 200 nautical miles be useful? (circle one)

Yes No

Specify optimal range. Please explain.

_____

_____

33.a. Did the forecast accuracy score match your impression of the actual forecast accuracy for the TRACON range? (circle one)

Yes No

If No, which of the following is true: (mark one)

_____ actual forecast was better than the forecast accuracy score

_____ actual forecast was worse than the forecast accuracy score

b. Did the forecast accuracy score match your impression of the actual forecast accuracy for the 200 nm range? (circle one)

Yes No

If No, which of the following is true: (mark one)

_____ actual forecast was better than the forecast accuracy score

_____ actual forecast was worse than the forecast accuracy score

THANK YOU FOR YOUR TIME, EFFORT, AND COOPERATION

If you are unable to return this questionnaire to an on-site FAA Technical Center Evaluator, please mail the completed questionnaire to the address below.

Cynthia Fidalgo, Raytheon Technical Services Co.
Weather Branch, ACB-630
FAA Technical Center
Atlantic City International Airport, NJ 08405

2000 TERMINAL CONVECTIVE WEATHER FORECAST DEMONSTRATION

Phase 2

MEMPHIS AIR ROUTE TRAFFIC CONTROL CENTER (ARTCC) TMU QUESTIONNAIRE

Prepared by:
Communication/Navigation/Surveillance
Engineering and Test Division, Weather Branch, ACB-630
William J. Hughes Technical Center
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

Instructions

The purpose of this questionnaire is to obtain feedback from users regarding the Terminal Convective Weather Forecast.

Feedback from users is a very important component of the Federal Aviation Administration (FAA) William J. Hughes Technical Center and the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) demonstration of the Terminal Convective Weather Forecast. Your responses to this questionnaire will provide important information for use in future iterations of the Terminal Convective Weather Forecast. Therefore, please respond to all questions as honestly and thoroughly as possible.

Responses to this questionnaire will remain ANONYMOUS and CONFIDENTIAL. A report will be written on the results of this questionnaire, summarizing respondents' comments; however no one will be identified or associated with any specific comment. **Please return the questionnaire to FAA the Technical Center Evaluator.**

Definition of Terms

Utility - This refers to how useful the TCWF is in completing job tasks related to traffic planning as impacted by convective weather. Elements of utility would include: 1) effect on situational awareness; 2) impacts on decision making; and/or 3) impacts on workload.

Ease of Use - This refers to how easy the TCWF is to use in completing job tasks (i.e. navigation, button use). For example, a user may consider a feature easy to use if he/she can discriminate display characters and symbols.

Readability - This refers to the extent the information displayed is easy to see, readable, meaningful, and understandable. For example, overlaid text may be too small to read or obscured by other overlays.

Situational Awareness - Situational Awareness, or SA, has been defined as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future. Essentially, it is how one perceives and understands elements in the present situation and uses this information to anticipate future events.

Terminal Convective Weather Forecast Information/Feature Definitions

1. **Display Window (Past/Forecast Weather) -** The display window is the region where the past weather and forecast weather are displayed. The window can display from 30 minutes of past weather to 60 minutes of forecasted weather.

2. **Forecast Accuracy Score –** The Forecast Accuracy Score provides real-time scoring information for both the 30 and 60-minute forecasts at TRACON and 200 nm ranges..

3. **Forecast Weather Color Scale –** The forecast weather scale shows regions in which the growth and decay tracker expects a moderate to high probability that level 3 weather (yellow on ITWS) will occur during the forecast time interval. Solid yellow is used for high probability regions while a hatched yellow/gray is used for moderate probability regions.

Terminal Convective Weather Forecast Information/Feature Definitions (Cont'd)

4. **Movie Loop** - The movie loop selections allow the user to select a variety of movie loops for displaying data. Loops range from past weather only to 30 or 60-minute forecasts. Past weather and forecasted weather can be looped together in 10-minute increments. Looping can occur with or without past weather.

5. **Relative Time Display** – The relative time display is located on the bottom left of the display screen. This display indicates relative time, or the time difference from the current time to the time of the weather shown in the display window. This time will be positive for the forecast images, and negative for past weather images. The font will be white when the images are looping and will turn red when the loop has been stopped.

6. **Start/Stop Loop Control** – The start/stop loop control function controls the starting and stopping of forecast loops. It also enables the user to display static forecast images.

7. **Overlays** - Overlays are accessed via the overlay menu and are user selected. Overlays consist of: jetways, victorways range rings, TRACON, outlying airports, counties, MEM sector, and states.

8. **Product Status Buttons** - Product status buttons are located on the status bar on the upper left side of the display. The buttons will be red if any product represented by the button is not available for Memphis airport in the display window. Green indicates product availability.

Product/Feature Utility, Ease of Use, and Readability

Instructions: The five-point scale below should be used to rate the ease of use and readability of the Terminal Convective Weather Forecast. Please refer to these definitions when responding. Please rate the product/feature by circling the appropriate number.

Rating Scale Definitions

5 – Totally Suitable. This response indicates the product/feature being rated is totally appropriate to support ARTCC Traffic Management Coordinators in the performance of their job tasks.

4 – Moderately Suitable. This response indicates the product/feature being rated is suitable with minimal negative impact and supports ARTCC Traffic Management Coordinators in the performance of their job tasks.

3 – Suitable with Modification. This response indicates the product/feature being rated is appropriate to support ARTCC Traffic Management Coordinators in the performance of their job tasks; however, modifications would improve the product.

2 – Moderately Unsuitable. This response indicates the product/feature being rated requires some significant change to provide appropriate support to ARTCC Traffic Management Coordinators in the performance of their job tasks.

1 – Totally Unsuitable. This response indicates the product/feature being rated has a significant negative impact to ARTCC Traffic Management Coordinators and will not support TMU job tasks.

NA - You have never used the product/feature in question.

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
1. Display Window (Forecast Weather)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
2. Relative Forecast Time Display						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
3. Forecast Weather Color Scale						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA

Products/Features	Totally Suitable	Moderately Suitable	Suitable with Modification	Moderately Unsuitable	Totally Unsuitable	
4. Movie Loop						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
5. Start/Stop Loop Control						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
6. Forecast Accuracy Score						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
7. Overlays (i.e. jetways, roads)						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
8. Windowing Options						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA
c. Ease of Use	5	4	3	2	1	NA
9. Product Status Buttons						
a. Utility	5	4	3	2	1	NA
b. Readability	5	4	3	2	1	NA

Utility Per Job Task

Instructions: The five-point scale below should be used to rate how useful the Terminal Convective Weather Forecast (TCWF), the ITWS Storm Extrapolated Position (SEP), and CWSU Forecast Information were in performing each of the specified tasks during convective weather. Please rate the aforementioned products INDEPENDENT of each other. For example, both the TCWF and the ITWS SEP can receive "Extremely Useful" ratings for a specific task if appropriate. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Extremely Useful. This response indicates the convective weather forecast information had a significant positive effect on decisions related to the specified job task.

4 – Somewhat Useful. This response indicates the convective weather forecast information had some positive effect on decisions related to the specific job task.

3 – Borderline. This response indicates the convective weather forecast information had little to no effect on decisions related to the specific job task.

2 – Of Little Use. This response indicates the convective weather forecast information had some negative effect on decisions related to the specific job task.

1 – Of No Use. This response indicates the convective weather forecast information had a significant negative effect on decisions related to the specific job task.

NA - You have never used the product in question.

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
10. Plan Aircraft Re-routes/Deviations						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
11. Anticipate Miles-In-Trail Restrictions						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
12. Open/Close/Reconfigure Arrival Transition Areas (ATA)						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Select Job Tasks	Extremely Useful	Somewhat Useful	Borderline	Of Little Use	Of No Use	
13. Open/Close/Reconfigure Departure Transition Areas (DTA)						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
14. Determine Holding Areas						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
15. Anticipate Airport Closures						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
16. Coordinate Military Release Areas						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
17. Aid Situational Awareness						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA
18. Other _____						
a. TCWF	5	4	3	2	1	NA
b. ITWS SEP (Light Blue Contour)	5	4	3	2	1	NA
c. CWSU Forecast Information	5	4	3	2	1	NA

Frequency of Use

Instructions: The five-point scale below should be used to rate the frequency (on average) in which the Terminal Convective Weather Forecast was used in performing the specific tasks listed. Please provide frequency ratings for TCWF use during CONVECTIVE WEATHER EVENTS only. Please refer to these definitions when responding.

Rating Scale Definitions

5 – Almost Always. This response indicates the TCWF was used at least 90% of the time when performing the specified task during convective weather events.

4 – Frequently. This response indicates the TCWF was used about 70% of the time when performing the specified task during convective weather events.

3 – Now and Then. This response indicates the TCWF was used about 50% of the time when performing the specified task during convective weather events.

2 – Seldom. This response indicates the TCWF was used about 30% of the time when performing the specified task during convective weather events.

1 – Hardly Ever. This response indicates the TCWF was used less than 10% of the time when performing the specified task during convective weather events.

NA - You have never used the TCWF operationally during convective weather.

Select Job Tasks	Almost Always	Frequently	Now and Then	Seldom	Hardly Ever	
19. Plan Aircraft Re-routes/Deviations	5	4	3	2	1	NA
20. Anticipate Miles-In-Trail Restrictions	5	4	3	2	1	NA
21. Open/Close/Reconfigure ATAs	5	4	3	2	1	NA
22. Open/Close/Reconfigure DTAs	5	4	3	2	1	NA
23. Determine Holding Areas	5	4	3	2	1	NA
24. Anticipate Airport Closures	5	4	3	2	1	NA
25. Coordinate Military Release Areas	5	4	3	2	1	NA
26. Aid Situational Awareness	5	4	3	2	1	NA
27. Other _____	5	4	3	2	1	NA

28. Given the types of decisions that you make, what length of forecast time is most desired? (circle one)

30 min. 60 min. 90 min. 120 min. Other _____min.

Why?_____

_____

29. What nautical mile range(s) do you use most often?

5 mi___ 15 mi___ 30 mi ____ TRACON_____ 100 mi____ 200 mi____

30. Would a range beyond 200 nautical miles be useful? (circle one)

Yes No

Specify optimal range. Please explain.

_____

_____

31.a. Did the forecast accuracy score match your impression of the actual forecast accuracy for the TRACON range? (circle one)

Yes No

If No, which of the following is true: (mark one)

_____ actual forecast was better than the forecast accuracy score

_____ actual forecast was worse than the forecast accuracy score

b. Did the forecast accuracy score match your impression of the actual forecast accuracy for the 200 nm range? (circle one)

Yes No

If No, which of the following is true: (mark one)

_____ actual forecast was better than the forecast accuracy score

_____ actual forecast was worse than the forecast accuracy score

THANK YOU FOR YOUR TIME, EFFORT, AND COOPERATION

If you are unable to return this questionnaire to an on-site FAA Technical Center Evaluator, please mail the completed questionnaire to the address below.

Cynthia Fidalgo, Raytheon Technical Services Co.
Weather Branch, ACB-630
FAA Technical Center
Atlantic City International Airport, NJ 08405

APPENDIX B

STRUCTURED INTERVIEW RESPONSES

TCWF 2000 Phase 1 Interview Responses - Memphis

A. MEM TRACON Interview Responses - Phase 1

Question 1. What is your overall impression of the TCWF?

User	Response
1	Very useful when weather is around the airport. Find it accurate.
2	Very useful.
3	Like it. Used on several occasions. Determines where weather will be for runway flow patterns. Useful.
4	It's awesome. Love it. It's great.
5	Love it. Use it whenever available. Wish it were in the Tower Cab.

2. Has the product helped you perform any specific tasks? If yes, what are those tasks and how did the TCWF help?

User	Response
1	Helped with general flow (flow control), aircraft holding, and to anticipate runway changes. Prediction of weather most helpful.
2	Used 2 or 3 times. Beneficial for holding airplanes and coming out of holds Forecasts are most helpful.
3	Yes, specifically runway flows, holding, and terminal routing, i.e., tells me where weather will be in the final approach corridor. Also gives advance notice of when weather will NOT be there.
4	Yes. Used to plan runway configuration and traffic management initiatives such as: timing AAR; predicting when to hold; and how many aircraft I can maneuver at a time.
5	Used for planning for weather, i.e., staffing. Helps determine landing and take-off direction. Use the 10-minute increments of weather prediction. Can do precise planning.

3. Has the product hindered your ability to perform any specific tasks? If yes, what are those tasks and how did the TCWF hinder them?

User	Response
1	No, so far. Also, there hasn't been a lot of weather.
2	No.
3	No.
4	No.
5	No. Usually low air-mass scores, so won't rely on in those situations.

4. Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial?

User	Response
1	Gives better idea of weather. Helps with decisions on routing. Smoothes out the operation. Can plan rather than react. Forecast and weather movement most useful.
2	Supplement to ITWS. Forecast and movement are most beneficial.
3	Yes. Is a good prediction tool. Gives picture of where weather will be in next 10, 20, or 40 minutes.
4	Yes. TCWF shows a visual prediction vs. prediction lines of ITWS. It's easier to understand a picture. The forecast and forecast counter (counts down) are most useful.
5	Good benefit with ITWS. ITWS is great but more real time. The forecast component of TCWF is a good supplement.

5. Has the TCWF enabled you to more efficiently handle the flow of traffic into or out of Memphis airport during convective weather? If yes, what information does the TCWF provide that helps?

User	Response
1	Yes, see above.
2	Yes. Better for making a judgment call based on the forecast. Makes job a little easier, e.g., knowing weather will be across final in 20 minutes.
3	Yes. See above.
4	Yes. See above.
5	Yes. Gives me more information to make decisions. I like the accuracy scores.

6. Could the TCWF be modified or improved to make it more useful? How?

User	Response
1	Predict gust fronts and wind - similar to ITWS. Would like it separate from ITWS. Easier than flipping through windows on 1 display. Prefer 2 separate monitors.
2	More training required. Use is hit or miss. The class was limited.
3	No. Don't think it would be good to integrate with the ITWS. Should test in an integrated mode if that is how it will eventually look. Would be useful in a Tower cab for runway selection. Would help in co-decisions between Tower and TRACON.
4	Would like to see TCWF integrated with ITWS on a separate window. Add wind information with direction, velocity and intensity to help predict runway shifts. Intensity levels are confusing. Use levels currently used on ITWS so not as much of an adjustment in interpreting them. Need better training - or trainers on site when system is operational and weather breaks. Would be good follow-up
5	No. Like the stand-alone display - two monitors side by side. Do not want to see integrated with ITWS.

7. Do you have any other comments or concerns regarding the forecast product?

User	Response
2	Every time used, the TCWF has been a benefit.

B. ZME TMU Interview Responses- Phase 1

1. What is your overall impression of the TCWF?

User	Response
1	Favorable. Used on a Fed Ex push where we were trying to get all arrivals in. Were able to get all but six in. Effectively used to reroute these aircraft. In this case, the product was accurate. The storm was a well-defined line from the southwest up the river, moving to the North and East slowly. This is an ideal situation for this product. Helped to manage the flow. Haven't used as much in air-mass conditions. During air-mass situations we are more reactionary. Planning is more dynamic than strategic.
2	Favorable. Works great. Am already sold on ITWS. Helped last night with microburst over the airport and the airport was about to shut down. Forecast was accurate. FAA should buy this.
3	Like it. Haven't used much.
4	Good. Is good with ITWS. Shows where weather is building. However, haven't used much.
5	Like the forecast mode. So busy there has been no opportunity to watch it. East and West coast routes force traffic on top of us. Spend a lot of time managing traffic volume.
6	Very good - like it. Better than ITWS. ITWS doesn't show motion or history.
7	Doesn't do anything for me. I don't base anything on the forecast. Accuracy scores are low, so can't base anything on that. I use ITWS.
8	When needed I used it - mostly for MEM. Would use more if I had more knowledge about it. Need to get more familiar with it. For enroute weather, I use the TSD

2. Has the product helped you perform any specific tasks? If yes, what are those tasks and how did the TCWF help?

User	Response
1	Last week, MEM was closed for 1 hr. and 15 min. due to air-mass conditions. TCWF was not used to forecast, however once the airport closed, the TCWF was used to see when to take planes out of holding. TCWF use is somewhat marginal but sometimes helps with planning.
2	Yes. Which routes to off-load. Where to hold airplanes. Good to establish time lines, especially for fuel critical conditions.
3	N/A
4	Not yet. Can see where it will. Am a little reluctant to use since it's experimental.

2. Has the product helped you perform any specific tasks? If yes, what are those tasks and how did the TCWF help? (Cont'd)

User	Response
5	Sometimes. When weather was going to impact a gate or weather headed to a southwest arrival fix (Marvel). Was looking at the storm prediction and movement - also intensity somewhat.
6	Really a terminal product. 90% of use is for MEM. Great to determine: When gates will shut off, Traffic flows, Runway configuration problems, Decrease in AAR. Can plan accordingly. Use the forecast and animated display. Easier to visualize.
7	Never used. If I didn't have ITWS, I would look at it.
8	Yes. Can anticipate gate closings and move planes to unaffected gates. Timing is helpful. Incremental forecast is beneficial. Used it along with MEM approach - we were both looking at the same picture and can focus on the same view. Projection of weather is good.

3. Has the product hindered your ability to perform any specific tasks? If yes, what are those tasks and how did the TCWF hinder them?

User	Response
1	No. Would never base a decision on one piece of information. TCWF is another tool. Gives a finer picture for timing.
2	Never
3	No.
4	N/A
5	No.
6	Not yet. Only use if weather is affecting MEM.
7	Saw it was inaccurate. Said weather would be impacting the field but it didn't.
8	No. Used with MEM approach - made a check and balance.

4. Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial?

User	Response
1	Not redundant with ITWS. If accuracy percentages are good, will use. Used for timing purposes, i.e., when will airport be closed.
2	Has benefit. Needs to expand beyond the terminal area. MEM is only 20% of our operations. Need a better prediction of where weather is going. Although the 30-minute forecast is more accurate, need the same reliability in longer-term projections.

4. Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial? (Cont'd)

User	Response
3	Yes, some benefit beyond ITWS. Forecast is a plus. Also, speed of movement. Allows for better timing, i.e., can tell airport will be closed in 30 minutes. Use the accuracy scores to base decisions on.
4	Yes. The 1-hour forecast and to see if weather is growing or decaying. Can look at gates to see where the weather will be and whether or when they will need to be opened or closed.
5	Yes, there is a benefit especially with the prediction mode.
6	See # 2
7	No benefit beyond ITWS. Forecast is the only benefit, but since it's inaccurate, there is no benefit.
8	Yes, is a benefit, but only for the airport.

5. Has the TCWF enabled you to more efficiently handle the flow of traffic into or out of your airspace during convective weather? If yes, what information does the TCWF provide that helps?

User	Response
1	Yes, in certain situations - when not hectic. Used for fine-tuning.
2	Yes. Even a lot of enroute traffic flies over MEM. 30 to 60 minute forecast is the most useful component.
3	Yes, mostly for terminal area. 200 nm is a little better but range needs to be greater.
4	Yes, helps in the terminal environment. Enroute is questionable.
5	Good for planning instead of waiting for approach control to call. Helped me prepare and knew what to do. More smooth and efficient.
6	Only MEM area. I have a problem with the display map. There is no MEM Center boundary map. Not a good quality map. In the long range, overlays are ineffective.
7	N/A
8	Only for MEM. Not used for departures but for arrivals and movement into the Terminal area.. For example, last night I knew the airport would be shut off in 10 minutes. I started holding planes without affecting the traffic flow. Was able to plan instead of react.

6. Could the TCWF be modified or improved to make it more useful? How?

User	Response
1	Selectability to tighter views. Show outlines of individual cells and trace cells better over certain areas of the airport. Tell when area will be clear or where weather will be, e.g., thunderstorms will be north of airport for next 20 minutes or so.
2	Improve accuracy and include a longer range. Integrate with ITWS
3	N/A

6. Could the TCWF be modified or improved to make it more useful? How? (Cont'd)

User	Response
4	Presently, don't know.
5	N/A
6	Bigger monitor.
7	If accuracy improved it may be better. Meant more for a terminal environment. I go with the TRACON decision and go with their flow. Most of us look at ITWS.
8	Don't know yet. When I become more familiar with it.

7. Do you have any other comments or concerns regarding the forecast product?

None of the ZME users had anything to add

MEM TRACON Interview Responses - Phase 2

1. What is your overall impression of the product? Has that impression changed since mid-July? If so, how?

User	Response
1	Awesome, great. Makes job easier since don't have to guess as much as to where convection will go.
2	TCWF is an asset to operations. Appears fairly accurate. A better initial briefing on the product would have helped in fully utilizing and understanding it.
3	Have not used much lately due to a lack of weather.
4	It is really good.
5	Good product.

2. Has the product helped you perform any specific tasks? If yes, what are those tasks and how did the TCWF help?

User	Response
1	Has helped in planning purposes; traffic flow; runway configuration (ITWS terminal winds are helpful, but TCWF helps additionally with forecasts of wind shifts)
2	A couple of times the product helped with holding at fixes; when to come out of holding; which fixes would open; when weather would leave the airport.
3	The 60-minute forecast enables planning with the Center if holding or spacing will be required
4	Runway changes; flow rates -- what to expect since Center determines; arrivals and departures; being able to predict where weather will be.
5	Determine opening and closing of gates for arrivals and departures; rerouting; can give Center an idea of when can open up arrival gates; is a good planning tool.

3. Has the TCWF enabled you to more efficiently handle the flow of traffic into or out of your airspace during convective weather? If yes, what information does the TCWF provide that helps?

User	Response
1	Absolutely, for arrivals and departures. TCWF is a visual aid. While forecast relative time is useful, the actual forecast time is very useful in determining when storms will impact airport and gates.
2	Yes, see responses to 2 above.
3	Helps due to planning.
4	Yes, see responses to 2 above.
5	Yes, would think so. In the past without TCWF, would use guess and experience to estimate how fast weather is moving.

4. Do you recall any convective weather scenarios that had impacted your airspace, specifically the MEM area

User	Response
1	Yesterday a line passed through. Was about 300-400 miles long. Was able to predict when aircraft could come out of holding. Nailed forecast with only 1 aircraft having to divert. Used in conjunction with ITWS, which gives intensity levels. TCWF used for about 70-80% of planning. Only other product is ASR-9 weather, which is really not used.
2	Used 3-4 times with line-storm situations. Used to determine going into holdings and coming out, and runway configurations. Also use the ASD. In addition, every night at 9 pm a conference call with Federal Express weather is held.
3	No situations recalled.
4	Not much weather lately. In early summer had a line of thunderstorms. Used TCWF in the ways identified in 2 above. Also used ITWS; ITWS SEP and TCWF in conjunction with one another
5	No recent weather that can recall.

5. Has the product hindered your ability to perform any specific tasks? If yes, what are those tasks and how did the TCWF hinder them?

User	Response
1	No.
2	No.
3	Is a hindrance only if it is wrong.
4	No.
5	No.

6. Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial?

User	Response
1	TCWF allows seeing the prediction rather than just the line of the SEP.
2	The forecast enables to know what is going to happen.

6. Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial? (Cont'd)

User	Response
3	Forecast since ITWS is only 20 minutes; TCWF gives longer time range. It gives a better idea of where weather will be, however, ITWS gives an idea also.
4	Cannot think of any other than the extended forecast that enables being able to predict where weather will be.
5	ITWS SEP is 10-20 minutes with only the leading edge; thus, doesn't give entire area, which TCWF does. ASR-9 prone to false weather information.

7. Did the 30 and 60 minute forecast accuracy scores effect your decision to use or not use the TCWF?

User	Response
1	No. Although one time when TCWF forecasts were not occurring as predicted, the accuracy scores reflected this with low scores. Was an air-mass situation. Actually increased confidence in the product since it showed the product knew it was not doing well.
2	Accuracy scores were high when TCWF was used. Was with the line-storms. Relied upon system due to high scores.
3	With low numbers does not depend on the product as much.
4	No. Referred to them and took with a grain of salt. Go ahead and make decisions based upon product image and can update in 30-40 minutes if was not accurate. TCWF is better than not having any information.
5	Does not really affect decisions. Tends to use 30 minute forecast; does not have much use for 60 minute forecast due to size of airspace.

8. Could the TCWF be modified or improved to make it more useful? How?

User	Response
1	Would like to have intensity levels. ITWS has wind direction and velocity, which is useful.
2	No. However, initial briefing was lacking; most learning was on-the-job picking things up.
3	Make available to controllers.
4	Make more user friendly. Not familiar enough or used enough to know how to change ranges and other options quickly. If does change something, cannot figure how to change back. Incorporating into ITWS may complicate both ITWS and TCWF; may want to keep separate in order not to lose usefulness.
5	Make TCWF more accessible to controllers, not to manipulate but to have display capability. A large screen capability would help. Would like to know source of weather being displayed, that is, is it from TDWR, WSR-88D, ASR-9. Probably should keep ITWS and TCWF as two separate displays. Never having seen integrated with ITWS, would not be sure how would work. TCWF works well displayed as is.

9. Do you have any other comments or concerns regarding the forecast product?

User	Response
1	If integrated into ITWS would need a larger monitor. The current scale (size) is nice, would not like to have a smaller version.
2	TCWF is a benefit to operations.
3	No.
4	Excellent piece of equipment.
5	Need rebriefing on product; for example not sure how to change and use looping capability. Tend to forget buttons if do not use often. Display is not intuitive; more use to drop-down menus, which spell out options.

ZME TMU Interview Responses - Phase 2

1. What is your overall impression of the product? Has that impression changed since mid-July? If so, how?

User	Response
1	Extremely helpful
2	Has no use for TCWF. It is an approach tool used for runway configurations due to wind shifts. MEM airspace is large, concentrating on one area does not help. Was adamant that on two previous occasions had told evaluators that the product was not useful.
3	Very little weather in the last 4 months, but prior to that was pleased with the product. Does not appear to be as accurate with sporadic (air-mass) thunderstorms as with lines. More confidence with the forecast of lines.
4	A good tool, useful.
5	Likes the product. Looks at it more than at ITWS.
6	Like a lot better than ITWS, has forecast which appears accurate.
7	Likes the product.
8	Has been pleased; there has been a number of occasions where the product has been helpful.
9	Likes it.
10	Impressed.
11	Very good.
12	Have not used TCWF much, only been in unit about 6 months; what has seen appears to be good.

2. Has the product helped you perform any specific tasks? If yes, what are those tasks and how did the TCWF help?

User	Response
1	Assists coordination with terminal facility (TRACON) through shared situational awareness; flow in and out of MEM; helps some with flow in and out of DFW and ATL; use for enroute of timing of aircraft if operating in MEM area; deciding whether to use miles-in-trail and holds.
2	N/A
3	Anticipation of impact of weather on arrival and departure gates; can pre-plan movement of aircraft
4	Estimate when weather will impact the airport at MEM; for holding aircraft; shutting off gates. TCWF is easier and more precise than MWP; shows weather in greater detail
5	Look at arrivals to see if need to plan; use TCWF forecasts to see if need to hold or not.
6	Plan off loads going to MEM; mainly with MEM inbound push; if TCWF shows convective weather over a gate in 30 minutes, than can adjust.
7	Yes, when a line of weather occurs at the same time as arrival bank at airport, then allows to be prepared to go into holding patterns. Aircraft from the east and northeast are impacted the most; can determine which ones can get in ahead of an approaching line and which ones will need to be rerouted; aircraft from the west tend to be trailing the weather so impact is not as great.
8	When airport will clear; what fixes will be impacted and when; helps in choosing when to move aircraft so can get into airport as quickly as possible when weather clears. Jet aircraft have many options, with TCWF can plan.
9	Forecasting when airport will go down; gate balancing; weather avoidance for arrivals
10	Yes, used for in and around MEM rather than whole job responsibilities.
11	Routes to MEM; miles-in-trail plans; talk to approach control; may affect departure routes.
12	No decisions, but have not had the opportunity.

3. Has the TCWF enabled you to more efficiently handle the flow of traffic into or out of your airspace during convective weather? If yes, what information does the TCWF provide that helps?

User	Response
1	Yes, see 2 above.
2	N/A
3	TCWF is used as a tool with lines; takes the information given as is and uses it.
4	Forecast movement is beneficial; presentation of gust fronts is helpful.
5	Yes, based upon TCWF forecast.
6	Yes, can pre-plan rather than react.
7	Yes, see 2 above; is a specific use, but an important one especially for hub airports.
8	Yes, see 2 above.
9	Yes, forecast allows to be proactive in bringing traffic on backside

3. Has the TCWF enabled you to more efficiently handle the flow of traffic into or out of your airspace during convective weather? If yes, what information does the TCWF provide that helps? (Cont'd)

User	Response
10	Yes, determining gates that may be closed.
11	Yes, see 2 above.
12	N/A

4. Do you recall any convective weather scenarios that had impacted your airspace, specifically the MEM area.

User	Response
1	Last night had a line of thunderstorms from about 100 miles south of MEM to about 80 miles north of MEM. Used to determine miles-in-trail and holding; were able to spread aircraft out to make a manageable situation; held aircraft and brought them in on the back side of the line; was able to minimize holding time and bring aircraft in as soon as weather cleared MEM. Product had good accuracy in this event.
2	Uses aircraft reports and lightning strike information. Does not rely on forecasts.
3	Yesterday's weather situation was a good example of how TCWF has been used. Was able to predict approximate times to move aircraft to gates; did not have to divert because of TCWF information.
4	N/A
5	Line of storms on 11/6 were forecasted accurately by TCWF; was only off by 10 minutes with airport arrival. Due to TCWF information, knew had to move aircraft north around line and bring aircraft in on backside of line; did not hold aircraft out in front of line. Relied solely upon the TCWF.
6	Predominantly light rain 2 days ago; did not have an impact so did not use product. Cannot recall any specific events.
7	See 2 above; describes exactly what happened. TCWF is very effective with line-storms.
8	Use ITWS, however, TCWF forecasts are easier; can tell if airport will be impacted and if need to use miles-in-trail and spacing. With ITWS, have to assume airport will be impacted due to the lack of forecast information. Line-storms tend to be more accurate; isolated storms are harder to predict, but if TCWF is forecasting something with isolated storms, then know to be aware.
9	Yesterday had a line; used as described in 2 above. CWSU provides information along with WARP. Will discuss TCWF with CWSU to see what they think. Refer to WARP to get bigger picture.
10	Did not use yesterday during weather event; weather was not intense enough, mostly just precipitation.
11	Any time there has been convective weather, has used TCWF to monitor the weather; passes information to other Centers to avoid overloading sectors; has used for justification to ATCSCC.
12	N/A

5. Has the product hindered your ability to perform any specific tasks? If yes, what are those tasks and how did the TCWF hinder them?

User	Response
1	No. Users realized that no product is 100%.
2	No
3	No
4	No
5	No
6	No
7	No
8	No
9	No
10	No
11	No
12	No

6. Has the TCWF provided benefit beyond ITWS? If yes, what features on the TCWF have been more helpful? If no, why is ITWS more beneficial?

User	Response
1	Forecast product, but still use in conjunction with ITWS.
2	N/A
3	No. ITWS gives winds, if TCWF included wind information that would be helpful. Presentation is more helpful than ITWS.
4	Does not always accept TCWF forecasts; waits and sees what the product is doing. Uses information as a possibility and consider what to do if forecast happens. TCWF does not add a lot over ITWS.
5	Gives a forecast that ITWS does not have; ITWS gives current weather, TCWF gives what will happen.
6	Forecast is only area
7	ITWS shows current weather, TCWF forecast is an enhancement.
8	Looping feature is helpful.
9	TCWF has enhanced features; forecast mode is the best; overall layout seems more user friendly; changing ranges is fairly easy; looping is beneficial.
10	Forecast is an advantage over ITWS; animation.
11	Longer forecast; uses ITWS and TCWF in a similar manner; CWSU turns TCWF on.
12	Forecast is better; very accurate.

7. Did the 30- and 60-minute forecast accuracy scores effect your decision to use or not use the TCWF?

User	Response
1	If low reliability, still use product but give less weight to forecast. If accuracy > 40%, then give more confidence. Acceptance of the reliability has improved.
2	Cannot base decisions on 40-50% forecast accuracy. Accuracy was not "there" so no confidence in product.
3	Does not pay attention to scores. If product is turned on, then it is for a reason and will trust the product.
4	No, does not watch forecast accuracy much.
5	Lack of scores affected confidence; was not there initially when thought should have been. If scores of 70 and higher, then have confidence in product.
6	No; product is accurate with lines; if not a line, then is not as accurate. Seems to do a better job with level 4 and above.
7	Yes; lines are more accurate than air-mass. This taken into account especially if numbers are down and at longer forecast times (> 40 minutes). With shorter forecast periods, tend to look more at how storms are tracking via the looping capability; looping is useful even for air-mass; user has to do some figuring for self by looking at trends in growth and movement.
8	Try to pay attention to scores; if not as accurate then do not pay attention to scores as much; hard to evaluate where a cut-off may be; when using TCWF, do not have time to look at scores; is using about 75% as a criteria, but have to use product over time to get comfortable with it.
9	Slightly; when weather exists, things are happening fast, may only glance at scores; if product shows something different than other sources then may look at scores.
10	Does not pay much attention to scores; is a waste of space.
11	Look mainly at the forecast display to see how well storms are being predicted; use scores less than 50% of the time.
12	No, not familiar with scores.

8. Could the TCWF be modified or improved to make it more useful? How?

User	Response
1	Prefers TCWF and ITWS on same monitor displayed side-by-side; likes size of current TCWF. ITWS runway winds use to be always available, now have to specify; would like to have wind information readily available.
2	N/A
3	Nothing aware of.
4	Would like to have at greater ranges. If could do mosaics of convective weather, that would be useful. Would like to have for more facilities.
5	No; have not used much due to lack of weather.
6	Move down from top shelf in TMU so can see it better.
7	No, happy with it.
8	Feels there is an accuracy issue; at what point is the product reliable; does not know what figures mean. Would like fixes on display so can know exactly where weather is. Likes having a separate display.

8. Could the TCWF be modified or improved to make it more useful? How? (Cont'd)

User	Response
9	No.
10	Would be good if had Center boundaries then could use for more of the airspace. Go farther back in time with animation; would like to see more history and less projection (only need out to 30 minutes). Would like to see one display; could replace ITWS.
11	Would like to see incorporated into ITWS, but can get too many windows.
12	Have county overlays.

9. Do you have any other comments or concerns regarding the forecast product?

User	Response
1	Outstanding system that needs to be implemented at other locations.
2	NA
3	When TCWF is used, it is effective and trustworthy.
4	Had questions about the extent of weather in the 200 nautical mile range. Does weather go out that far?
5	Really like it.
6	Has performed as advertised.
7	NA
8	Federal Express is a big customer; TCWF has been beneficial for late evening arrival pushes. Would be beneficial for Federal Express to have.
9	NA
10	Lines on maps are too thin; improve the maps.
11	NA
12	Anything is an improvement, but overall has not used much.

APPENDIX C

SAMPLE MODIFIED COOPER HARPER (MCH) WORKLOAD SCALE MEM TRACON

Modified Cooper Harper (MCH) Workload Scale

Operator mental workload is one component used to assess the suitability and effectiveness of an operational system. In order to ensure that mental workload for the Air Traffic Control Traffic Management Coordinator (TMC) or ATC Supervisor has not increased with use of other systems product, the Modified Cooper Harper (MCH) workload scale is being administered to measure overall operator mental workload. The MCH scale will be administered twice: 1) prior to Demonstration conduct, and 2) post- Demonstration conduct.

Instructions

Consider your perceived workload given moderate to severe convective weather conditions. After reading the difficulty level and operator demand level descriptions, please indicate workload ratings for each of the ATC tasks by circling the number (1-10) on the right hand side of the scale. Based on these descriptions, choose the rating number that most closely matches your perception of mental effort in performing these tasks. Each task is listed on a separate page accompanied by the workload rating scale. Please read the descriptions on difficulty level and operator demand level carefully before circling your rating score.

1. Change runway configuration

DIFFICULTY LEVEL	OPERATOR DEMAND LEVEL	RATING
VERY EASY, HIGHLY DESIRABLE	OPERATOR MENTAL EFFORT IS MINIMAL AND DESIRED PERFORMANCE IS EASILY ATTAINABLE	1
EASY, DESIRABLE	OPERATOR MENTAL EFFORT IS LOW AND DESIRED PERFORMANCE IS ATTAINABLE.	2
FAIR, MILD DIFFICULTY	ACCEPTABLE OPERATOR MENTAL EFFORT IS REQUIRED TO ATTAIN ADEQUATE SYSTEM PERFORMANCE	3
MINOR BUT ANNOYING DIFFICULTY	MODERATELY HIGH OPERATOR MENTAL EFFORT IS REQUIRED TO ATTAIN ADEQUATE SYSTEM PERFORMANCE	4
MODERATELY OBJECTIONABLE DIFFICULTY	HIGH OPERATOR MENTAL EFFORT IS REQUIRED TO ATTAIN ADEQUATE SYSTEM PERFORMANCE.	5
VERY OBJECTIONABLE BUT TOLERABLE DIFFICULTY	MAXIMUM OPERATOR MENTAL EFFORT IS REQUIRED TO ATTAIN ADEQUATE SYSTEM PERFORMANCE.	6
MAJOR DIFFICULTY	MAXIMUM OPERATOR MENTAL EFFORT IS REQUIRED TO BRING ERRORS TO MODERATE LEVEL.	7
MAJOR DIFFICULTY	MAXIMUM OPERATOR MENTAL EFFORT IS REQUIRED TO AVOID LARGE OR NUMEROUS ERRORS.	8
MAJOR DIFFICULTY	INTENSE OPERATOR MENTAL EFFORT IS REQUIRED TO ACCOMPLISH TASK, BUT FREQUENT OR NUMEROUS ERRORS PERSIST.	9
IMPOSSIBLE	INSTRUCTED TASK CANNOT BE ACCOMPLISHED RELIABLY.	10